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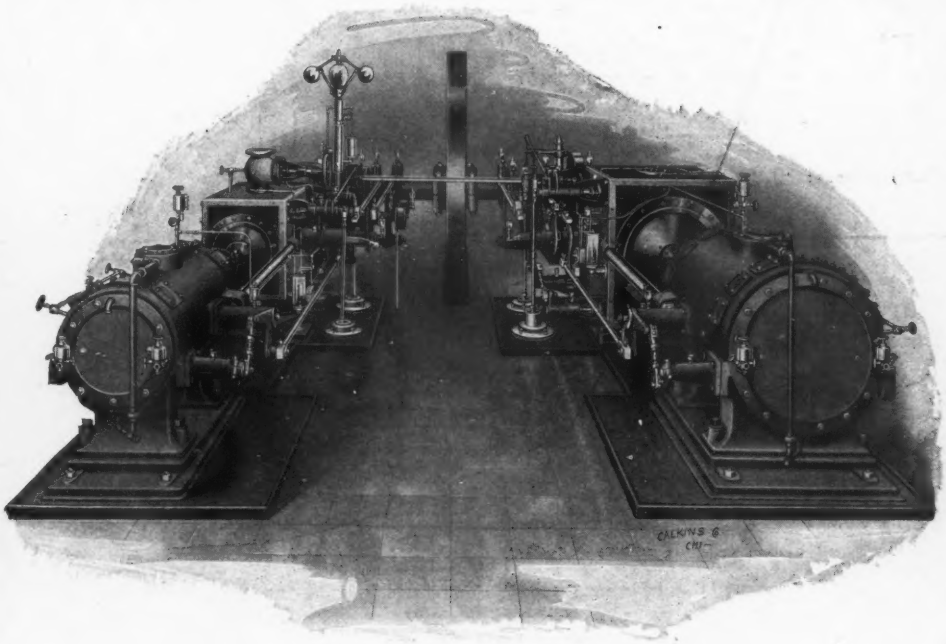
COMPRESSED AIR MAGAZINE

DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

Vol. XVI FEBRUARY, 1911 No. 2

Franklin Air Compressors



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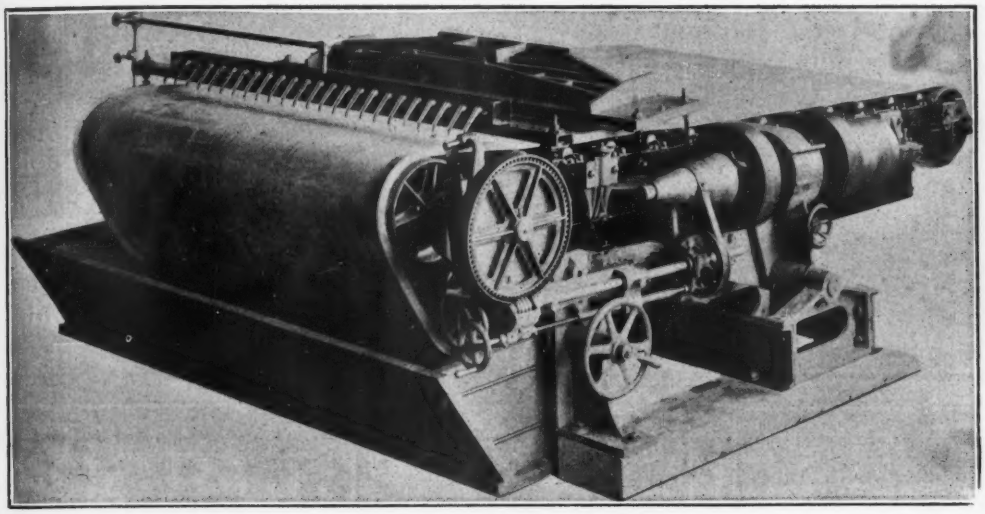

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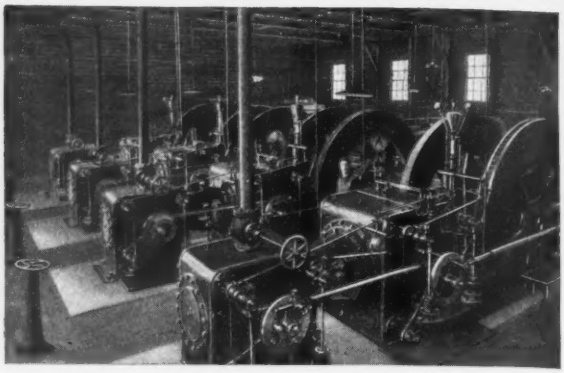

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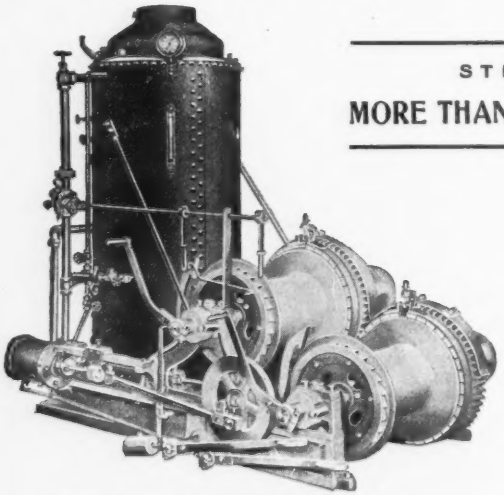

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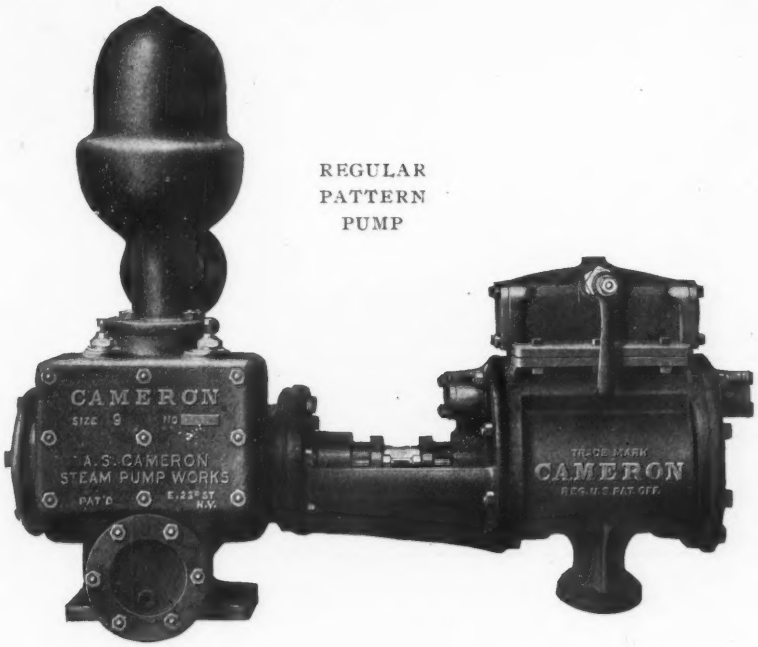

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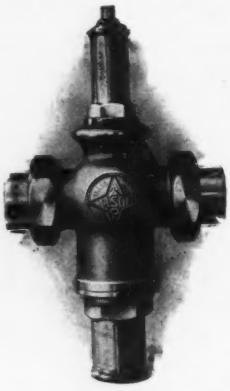

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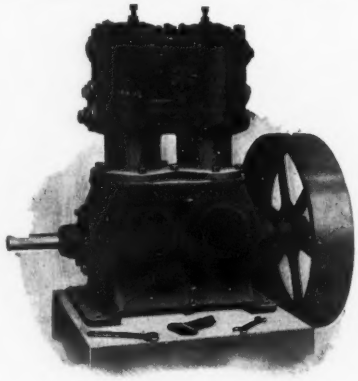

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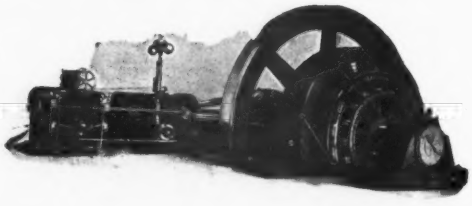

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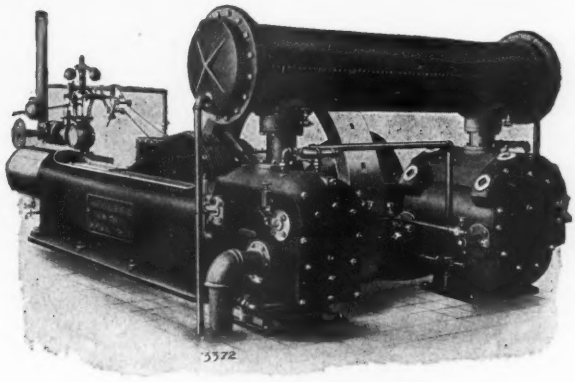

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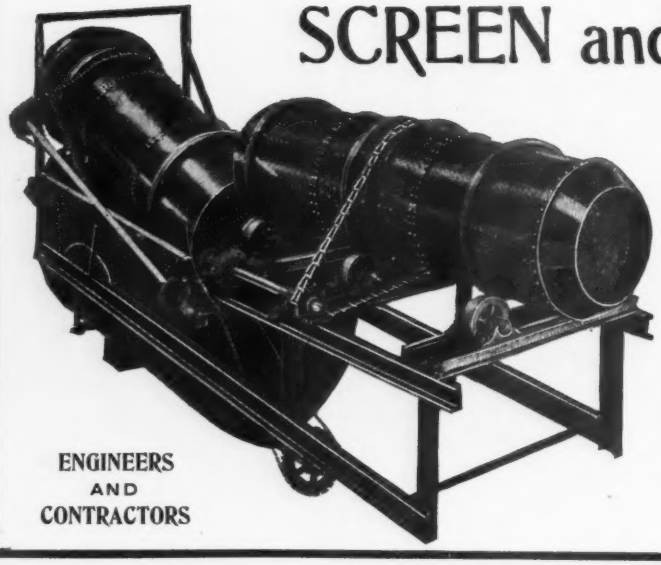

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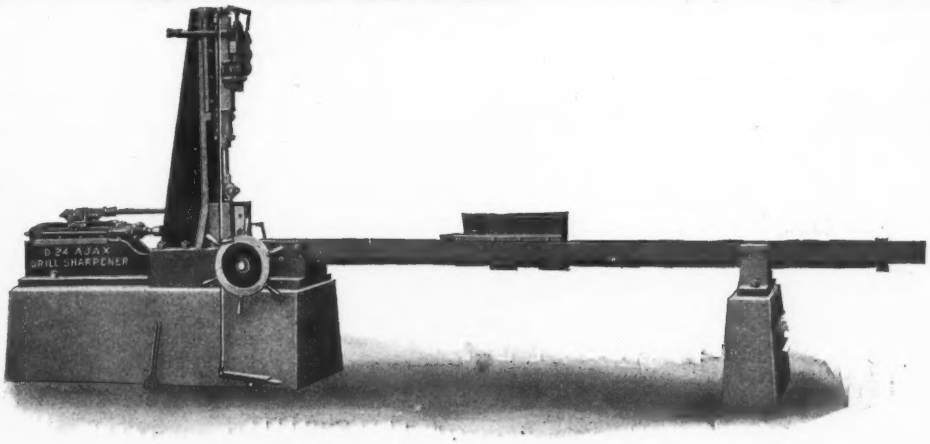

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COMPRESSED AIR PLANT

THE PRODUCTION, TRANSMISSION AND USE OF COMPRESSED AIR, WITH SPECIAL REFERENCE TO MINE SERVICE

BY

ROBERT PEELE

Mining Engineer and Professor of Mining in the School of Mines, Columbia University

As compared with the first edition the size of the second edition is increased 174 pages and the illustrations increased 97 figures.

The price is advanced from $3.00 (12/6 net) to $3.50 net (15/- net).

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PREFACE TO THE SECOND EDITION

This edition has been revised and substantially enlarged. Among the principal additions are some 90 pages of text and 63 illustrations, relating to the construction and operation of rock-drills, coal-cutting machines and channeling machines. This material is contained in Chapters XX, XXI, XXII, and XXIII. The detailed records of work of machine drills, in Chapters XX and XXI, I believe, will be found useful. Most of the data has not before been in print.

In Chapter III the theory of the compression of air is presented in greater detail, together with its applications to the operation and performance of compressors. The deductions of the more important formulæ are also given, such as those used for calculating the horse-power required for single- and multiple-stage compression. In this connection I desire to acknowledge the kind assistance of Professor Charles E. Lucke, of Columbia University, and Professor H. J. Thorkelson, of the University of Wisconsin. To Dr. Lucke my thanks are due for the use of his valuable, and hitherto unpublished, notes relating to the work cycles of air compression, with and without clearance. I would call attention also to the records of compressor tests in the latter part of Chapter X. These comprise a few typical tests, selected from a large number recently made by Mr. R. L. Webb, Mechanical Engineer, on compressors of different kinds in a well-known Canadian mining district.

Other new material has also been added, relative to the piston clearance of the air cylinders of compressors, and the ratio of inlet valve area to cylinder area. Numerous minor additions to the text have been made, together with corrections and alterations where required. The new matter aggregates some 135 pages of text and 87 illustrations. Many of the illustrations have been furnished by the respective makers of the machinery, to whom credit is duly given. In preparing this revision I have kept in mind certain kindly criticisms and suggestions received from readers of the first edition.

R. P.

NEW YORK, June, 1910.

8vo, xvi + 502 pages, 209 figures. Cloth, $3.50 net (15/- net)

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Vol. XVI FEBRUARY, 1911 No. 2

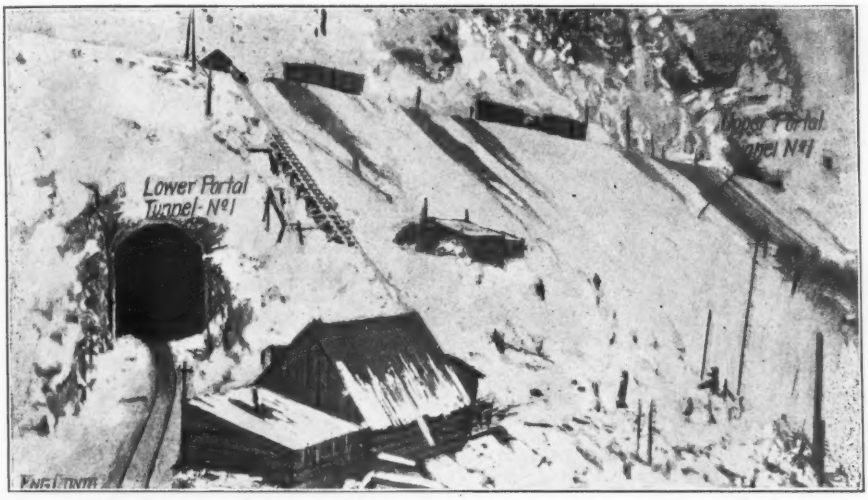


FIG. 1. BOTH PORTALS OF TUNNEL NO. 1.

THE SPIRAL TUNNELS OF THE CANADIAN PACIFIC RAILWAY

The completion of two spiral tunnels on the Canadian Pacific Ry., which are a part of the relocated line through the Selkirk Mountains in British Columbia, eliminates one of the steepest grades (4.5 per cent. compensated) on any standard gage railway. The following account of the construction of these tunnels we abstract from an authorized article in a recent issue of *Engineering-Contracting.*

The tunnels are built on 10° curves and a grade of 2.2 per cent., which, in the tunnels, is reduced to 0.06′ per degree of curvature or to a grade of 1.6 per cent. The length of tunnel No. 1, is 3,206 ft. and the length of No. 2 is 2,890 ft. In section the tunnel is 22 ft. 6 ins. wide and 16 ft. 3 ins. high to the springing line, with a semi-circular arch of 11 ft. 3 ins. radius. Where timbering was not necessary these dimensions were somewhat less, but allowed for the placing of a future concrete lining, 2 ft. thick, as shown by the section in Fig. 3.

The tunnels were driven through crystallized limestone which was somewhat uniform in tunnel No. 1, with a dip of 20° to the northeast, but which in tunnel No. 2 was very irregularly stratified. The strike, of course, was made at angles to the face, as each tunnel made a turn of over 230°. Work on tunnel No. 1 was commenced in January, 1908. The work on both tunnels was prosecuted continuously from that time until June, 1910, when the tunnels were completed. Tunnel No. 2 was started a month later and finished a month earlier than tunnel No. 1. An average of 176.9

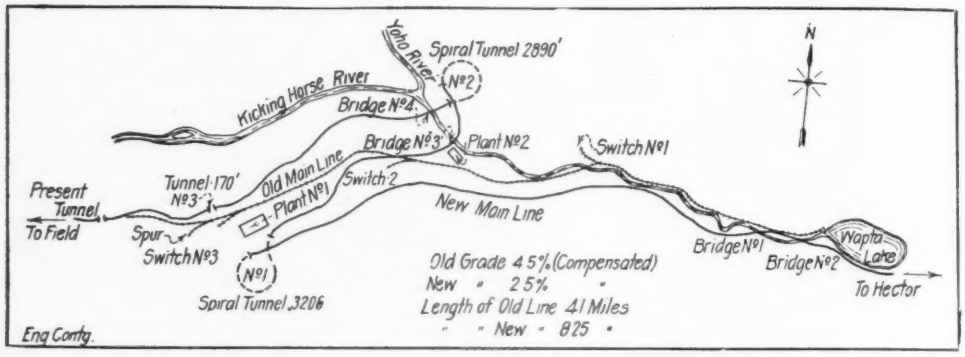


FIG. 2. PLAN OF OLD AND NEW LINE.

ft. per month was made on tunnel No. 1 for 18 months, and 171.3 ft. per month progress was made on tunnel No. 2 for 17 months. Each tunnel was worked with two headings.

It was first intended to do the mucking by hand but after a short trial it was decided to install four Marion shovels for this purpose. These shovels were operated by compressed air and their use necessitated doubling the compressor and boiler capacity of the plant. The plant furnishing compressed air and light to tunnel No. 1 was located near switch No. 3 of the old railway line as shown by Fig. 2. This was about 250 ft. below the elevation of the tunnel portal. The plant for tunnel No. 2 was located at the river about 1,500 ft. from the portal. A list of the entire plant used is as follows:

Boilers:

2 100 hp. (return tubular).
4 80 hp. Jencks locomotive type.
2 100 hp. Jencks locomotive type.
1 100 hp. Brady-Mumphard.

Engines:

1 Comstock Climax engine; 7x10 ins., 25 hp.
1 Comstock Climax engine; 4x5 ins., 4 hp.
1 American hoisting engine with boiler; 7x10 ins., 25 hp.
1 Little Giant Hoisting engine; 5x7 ins., 8 hp.

Air Compressors:

1 Straight line, Ingersoll-Sergeant (24 and 26½x30 ins.); capacity 1,425 cu. ft. free air per min.
1 Straight line, Ingersoll-Rand (20 and 20 x30 ins.); capacity 1,100 cu. ft. free air per min.
1 Cross-compound American-Rand; air cylinders 22 and 13x16 ins.; steam cylinders 14 and 24x16 ins.; capacity 1,050 cu. ft. of free air per min.

Pumps:

1 Atlantic, 7x4½x6 ins.
8 Fairbanks-Morse duplex; 6 ram pattern; 2 piston plunger pattern; 6x4x6 ins. to 8x5x12 ins.

Generators:

2 Westinghouse d. c., 6 kw., 125 volts.
1 General Electric d. c., 25 kw., 250 volts.

Drills and Shovels:

22 Canadian-Rand Little Giant rock drills.
6 Ingersoll-Sergeant rock drills.
4 No. 20 Marion steam shovels (operated by air).

The effect of the 6,000 ft. elevation above sea level and the cold winter was shown on the mechanical equipment. The effect was in the reduction of the atmospheric pressure about 3 lbs. per sq. in., and a reduction of the temperature. During very cold weather difficulty was experienced by the freezing of the moisture in the air lines. This trouble occurred where the pipes were practically level, but not inside the tunnels. In order to obviate this difficulty additional air receivers were placed in the lines, but they served only partially to overcome it.

The top heading and bench method was used in driving the tunnel. The heading included the area described by the semicircular arch, and the bench included the balance of the tunnel section. Two shifts of 10 hours each were worked each day, with the exception of the shovel crews, who mucked their round. In each heading 6 to 8 drills on four columns were used, with 1 driller and 1 helper for each drill used. Figure 3 shows the approximate location of the drill holes for both tim-

bered and untimbered sections. There were two rows of cut holes about 12 ft. deep. The cut holes were from 2 to 3 ft. from the center line and were "cut" so as nearly to cross the center line. The location of the side holes was varied considerably according to the character of the rock.

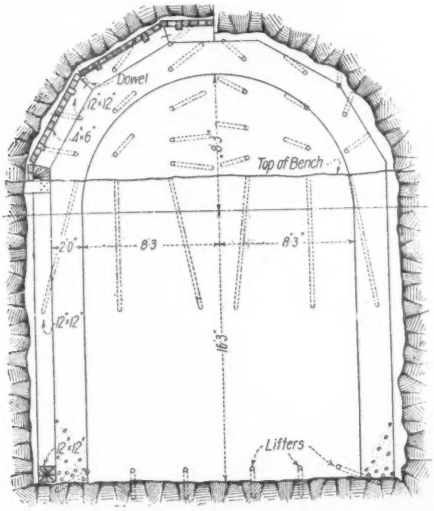


FIG. 3. TUNNEL SECTION.

The bench, which was kept 10 to 12 ft. back from the face of the heading, was drilled with 6 down holes sloped as shown by Fig. 3; also a row of 6 lifter holes, 12 ft. deep, pointed so as to reach about 1 ft. below the sub-grade. The rock was crystallized limestone and very brittle. The center line of the tunnel being, as it was, on a circular arc, the rock strata were encountered at all angles to the drill holes and small pieces broke off inside the holes and jammed the bits. Various shapes of bits were tried, but the use of small pieces of iron, thrown into the hole, proved most effective.

The shovels were used almost entirely for the mucking, with the exception of sufficiently mucking back from the heading to allow the setting up of the drills, and this was done by the drillers and helpers.

The mucking was usually completed by the time the down holes in the bench were drilled and the shovel was then moved back about 150 ft. until the lifter holes were drilled and all holes were fired.

The cut holes were loaded for springing. They were then sprung and fired. The side rounds, the down bench holes, and the lifters were shot at one time. The bench, being kept close to the heading, allowed the muck to be thrown down with that from the bench. The bench was kept as nearly vertical as possible.

The shovels were equipped with special short booms and dipper arms, and shallow dippers for rock work. They were equipped for operation by steam, but the boiler was used as an additional receiver for the compressed air. The shovels were operated on a track close to one side of the tunnel and each was supported on the inner side by a jack. A narrow gage (2 ft.) double track was used for the 4-yd. home-made dump cars, and this track was kept close up to the shovel. At the end of this track, near the bench, it merged into a single track used for loading. Cars came in on one track and went out on the other, requiring about 1 minute for an exchange of single cars. The cars were pulled up grade by horses and ran down grade by gravity.

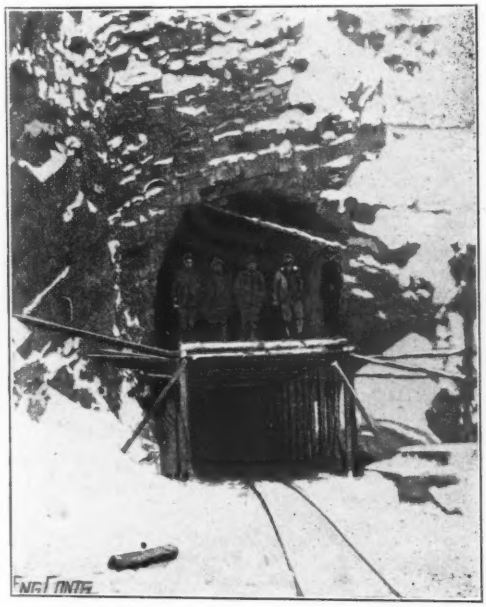


FIG. 4. UPPER PORTAL NO. 1 TUNNEL.

About 25 per cent. of the tunnels required timbering. When this was done the bench was left about 50 ft. from the heading. The permanent timber plates were put in, each segment was trimmed off and was then lagged and wedged up. Before shooting the bench the wall plate was securely blocked up and

the last full length post was protected by old timbers laid against the walls.

When a 50-ft. bench was used the muck from the heading had to be wheeled back in wheelbarrows and dumped over the bench where it could be handled by the shovel. The size of the timber gang varied according to the conditions. Part of the timbering had to be kept close up to the work to support the ground, but for a certain portion it was possible to wait until the excavation had been completed. In this case a "jumbo" car was used to facilitate the handling of timbers and packing. The timbers for the tunnel work were cut from the surrounding mountains.

Water troubles took care of themselves in the headings going up grade, but in the down grade headings sump holes (3x3x3 ft.) had to be made. The sump holes were excavated from time to time as the heading progressed and the water running into these was kept down by pumps operated by compressed air.

The headings all closed within ¾ in. for alinement and the error in closing the grades was practically nothing. The contractors for the entire work were Mcdonnell, Gzowski & Co. of Vancouver, B. C. We are indebted to Mr. C. S. Gzowski, a member of the firm, for the information given.

THE UTILIZATION OF ATMOSPHERIC NITROGEN

BY SAUL DUSHMAN

During the last few years a large number of processes have been devised for the utilization of atmospheric nitrogen. The motives for these processes have been two-fold: both in fertilizers and in explosives nitrogen forms a very important constituent. Nitre or Chili saltpeter has been the substance chiefly used for these purposes in the past; but the nitre beds are gradually becoming exhausted, and the world has come to realize that some other source of fertilizers must be sought for if its food supply is to remain assured. At the same time there exists a continually increasing demand from the manufacturers of explosives, for a concentrated nitric acid.

As far back as 1776, Cavendish, the famous English physicist, discovered that an electric spark passed through a moist mixture of oxygen and nitrogen produces nitric acid, and at least three processes are in commercial operation which are based upon this reaction. In the process devised by Birkeland and Eyde in 1904, a 5,000-volt alternating current is passed between water-cooled copper electrodes and, by means of a magnetic field at right angles to the latter, the arc is spread out into a disc of over two meters in diameter, thus causing almost the whole volume of air in the furnace to be raised instantaneously to a very high temperature. About one per cent. of the air passing through the arc is thus converted into oxides of nitrogen, which are then washed out by passing the gases from the furnaces through a series of towers. There is obtained in this manner a 50 per cent. nitric acid, which is converted into calcium nitrate by neutralizing with lime. The latter is used as a fertilizer directly. The furnaces used by Birkeland and Eyde were originally of 500 k. w. capacity, but subsequently they were replaced by 800 k. w. units, and at the present time it is the intention to replace these by 1,600 k. w. furnaces. In the first commercial installation at Notodden, Norway, only 1,500 k. w. was used; afterwards this was increased to 40,000 k. w. During 1908, the first year of operation, the total income was $536,000, and the net gain, $134,000. Plants have been established at numerous other places in Norway, where water-power is available, and according to most recent reports the Norwegian industry of manufacturing air nitrates is undergoing rapid extensions involving the expenditure of nearly $15,000,000. Not only calcium nitrate, but also more concentrated nitric acid, nitrate of ammonia, nitrate of potash, as well as sodium nitrate are being manufactured at these plants. One of the principal reasons for the success of the process in Norway is undoubtedly the small cost of power which is said to be available at about $5 per horsepower year.

Another process based upon the same fundamental principle is that developed very recently by the Badische Anilin-und Soda-Fabrik. "In this process a continuous arc is produced in a long tube by first bringing electrodes together and then gradually moving them along the tube while the other remains fixed at one end of the tube. The current of air, instead of being passed through this arc, is passed around it through the tube by being forced in at an angle to the main axis of the tube. It is said that the arcs used in this process vary from 35 to 50 feet or more in

length, and are maintained continuously for days or even months at a time."

Besides these two processes which are both in successful commercial operation, there is a third process for the oxidation of atmospheric nitrogen which has been devised by H. and G. Pauling, and is working on a large scale near Innsbruck in Tyrol. The electrodes are curved like the electrodes of the so-called horn lightning arresters. The arc is started at the narrowest part between the electrodes by means of a special lighting device. The air current passed through the arc blows it out to a considerable distance and thus increases the volume of air heated to the extremely high temperature at which combination occurs. "The twenty-four furnaces at present installed in this plant have a total capacity of 15,000 h. p. Two other plants, each of 10,000 h. p., for carrying out the same process, are in course of erection, one in Southern France, and the other in Northern Italy."

The process of Frank and Caro for the utilization of atmospheric nitrogen is totally different from any of the above methods. Nitrogen is passed over heated calcium carbide and the result is the formation of a substance having the formula $CaCN_2$ and known as cyanamide. Investigations at numerous agricultural stations have shown that it can be successfully used as a fertilizer, and accordingly a large number of plants are being erected both in Europe and America for its production. The United States Cyanamide Company has a 5,000-tons works at Niagara Falls, Ontario, and is also building another plant in Tennessee. Cyanamide is also of interest on account of the number of interesting derivatives which it is capable of yielding when treated with different reagents. An important reaction is that with steam, leading to the formation of ammonia, which may be subsequently converted into ammonium sulphate.

Still another method for the utilization of atmospheric nitrogen has been devised recently by F. Haber and patented by the Badische Anilin-und Soda-Fabrik. A mixture of nitrogen and hydrogen in the required proportions is maintained at a constant high pressure and heated in presence of a catalytic reagent (such as finely divided iron or osmium) to a temperature which varies between 400 degrees and 800 degrees C. Only about 8 per cent. of the mixture is converted into ammonia, but the power necessary for the compression and circulation of the resulting gases is very small, and it appears very likely that in the near future this process will be exploited industrially.—*Eng. Soc. University of Toronto.*

PROGRESSIVE AIR BRAKE REQUIREMENTS

In a paper before the Franklin Institute on Air Brakes Mr. Walter V. Turner, chief engineer of the Westinghouse Air Brake Co., said, as one of many topics spoken of, that facilities for controlling railroad trains have not advanced relatively as have the requirements, and that, as a mattter of fact, the brake has not kept pace with the developments in locomotion. Even the most efficient brake of today is, at its best, not able to control and stop a train in as short a distance as when the weight and length of the train was less than one-fourth of what it now is. That the stopping distances of modern heavy high-speed trains are not longer than they are, is a source of gratification when it is considered that the length of the train and the volume of air to be handled in controlling the train have rendered the problem vastly more difficult, so far as service control is concerned, and the increase in weight and speeds is such as would require at least twice the distance in which to stop modern high-speed passenger trains, if the old type of brake had to be used.

In one of the earliest brake trials in the history of continuous brake, made on the Midland Railroad near Newark, England, in 1875, a stop was made from 53 miles per hour (the highest that could be obtained) in 18 seconds. [In this time the train at full speed would have run a little over a quarter of a mile, but the actual distance before complete stoppage would, of course, be considerably less than this on account of the gradually diminishing speed.—Ed. C. A. M.] This corresponds to 15.5 foot-tons of work per brake shoe per second. To stop a modern train of heavy Pullman cars from a speed of, say, 75 miles per hour (which can be obtained under favorable conditions) in the same time, namely, 18 seconds, would require about 4½ times as much work per brake shoe per second as in the case of the Midland Railway train. The tremendous significance of this increase in power demanded is but one aspect of the question and is mentioned simply to indicate the nature of the problem which must be solved.

HUMPHREY INTERNAL COMBUSTION PUMP AND AIR COMPRESSOR

The following description of the Humphrey pump and air compressor is from a paper by its inventor, Mr. H. A. Humphrey, before the Manchester (Eng.) Association of Engineers.

The simplest form of Humphrey pump is shown in Fig. 1. Imagine a charge of gas and air to be compressed in the top of chamber C and fired by a sparking plug projecting through the top casting. All valves are closed when the explosion occurs and the increase in pressure drives the water downwards in C, setting the whole column of water in the discharge pipe D in motion. The column attains kinetic energy while work is being done on it by the expanding gases, and may move with considerable velocity when these have reached atmospheric pressure. The motion of the water column cannot be suddenly arrested, hence the pressure in the combustion chamber C tends to fall below that of the atmosphere, the exhaust valve E opens, and also the water valves VV in the supply tank ST. Water rushes in through VV mostly to follow the moving column in pipe D, but partly to rise in C in an effort to reach the same level inside the chamber as exists in ST.

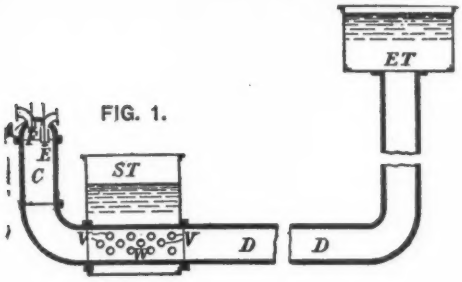
When the kinetic energy of the moving column has expended itself by forcing water into the high-level tank ET it comes to rest, and there being nothing to prevent a return flow, the column starts to move back towards the pump, and gains velocity until the water reaches the level of the exhaust valve, which it shuts by impact. A certain quantity of burnt products is now imprisoned in the cushion space F, and the energy of the moving column is expended in compressing this gas cushion to a greater pressure than that due to the static head of the water in tank ET. Hence a second outward movement of the column results, and when the water reaches the level of valve E the pressure of the space F is again atmospheric, and further movement of the water opens valve A against a light spring, and draws in a fresh charge of gas and air. If there were no friction, the water would fall to the same level as that from which the last upward motion started, but the amount of combustible charge drawn in is slightly less than this movement would represent. Once more the column of water returns under the elevated tank pressure, and compresses the charge of gas and air, which is then ignited to start a fresh cycle of operations.

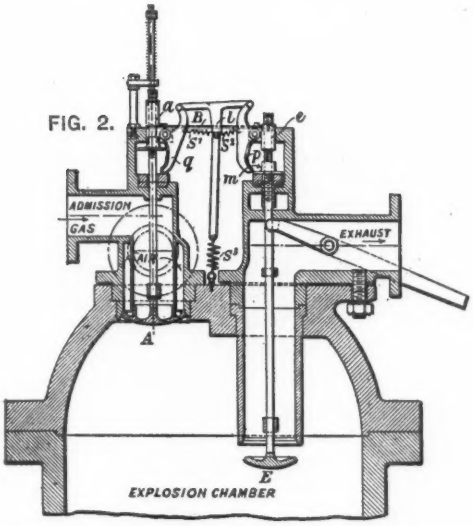
The action of the pump is not altered if, instead of delivering into an elevated tank, it discharges into an air vessel, or into an open-top standpipe or tower, and both these arrangements are useful if a continuous flow from the outlet is desired.

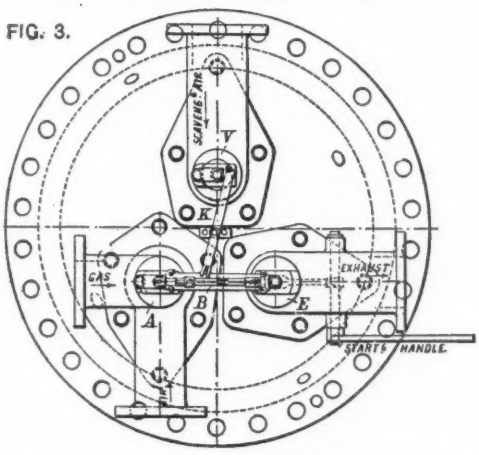
In the simple form of pump the degree of compression of the combustible charge prior to ignition depends on the height to which the water is raised, and exceeds the static equivalent of the head. This is obvious if one remembers that the kinetic energy acquired by the liquid column on its return flow is utilized in compressing the combustible gas, while the compression brings the column to rest.

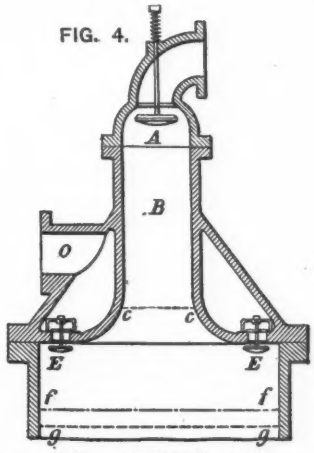
The same considerations enter into the question of the cushion pressure attained, but here we are dealing with the compression of a volume of gaseous fluid which occupies the clearance space only, and the stroke of the water column is greater in proportion, because for the first part of the stroke exhaust products are being expelled, and no compression occurs. The cushion pressure rises rapidly as the height to which the water is lifted increases, and at the maximum lift of about 40 ft. to which the simplest type of pump is limited, it may exceed the explosion pressure when using producer-gas, or may approximately equal the explosion pressure when working with city gas or gasoline.

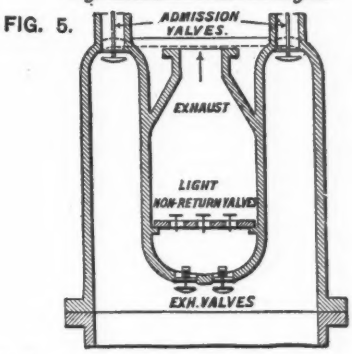
A Humphrey pump was exhibited in operation at the Brussels International Exhibition, and obtained two "highest possible" awards—namely, a Grand Prix in the class for gas-engines, and a Grand Prix in the class for pumps. Its construction is similar to that in Fig. 1, and explanation is not needed till we come to the valve gear shown in Figs. 2 and 3. It will be observed that a bolt B sliding horizontally must lock either the admission-valve A or the exhaust-valve E by engaging under collars *a* or *e*, which are fixed on the stems of their respective valves. Now the bolt is urged right or left, according to whether spring s_1 or s_2 is pulling the hardest, and this again depends on whether the link *l*, to which the springs are attached, has been shifted to the right or left. Suppose the exhaust-valve opened last, then its washer *m*, engaging against cam arm *p*, moves the system *p*, *l*, *q*, so that it leans to the right, in which position it is re-

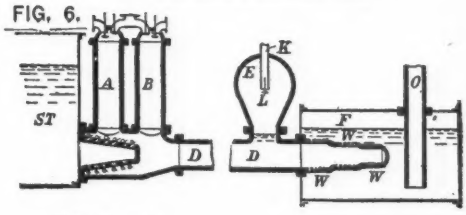


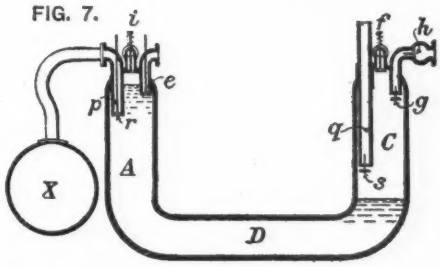












HUMPHREY GAS EXPLOSION PUMPS AND AIR COMPRESSORS.

tained by the tension of spring s_3. This puts tension on spring s_1 and loosens spring s_2; bolt B, therefore, tries to move to the right, but until the exhaust-valve shuts it can only press upon collar c. However, when valve E comes on its seat the bolt instantly locks under e, and the same motion which holds valve E shut has released valve A, so that next time a suc-

tion occurs in the combustion-chamber, A only can open. Precisely the same kind of action occurs when A shuts and is locked and E is released again. Thus valves A and E are automatically allowed to act alternately, the difference between them being that while E remains open till shut by the rising water, A shuts under the action of its supporting spring, so soon as the suction in the chamber permits the spring to lift the valve to its seat.

The scavenging-valve V is shown in the plan of the combustion-head, Fig. 3, and as it operates at the end of each expansion stroke, its locking and release periods correspond with those of the exhaust-valve, and are made simultaneous by a lever pivoted at K, and operated by a pin on the bolt B. If the water could rush in fast enough when the pressure falls to atmosphere, there would be no scavenging action; but the incoming water has to be accelerated, and that just gives rise to a sufficient suction to effect the desired scavenging. In the exhaust outlet there is a light non-return valve, to prevent burnt products being drawn back into the chamber.

Figs. 4 and 5 show alternative arrangements of the top of the combustion chamber for a two-cycle pump requiring no valve gear. The combustion chamber has to be specially shaped, so that the incoming charge, which may be preceded by pure air, displaces the burnt products and mixes as little as possible with them. Thus, in Fig. 4, A is the admission valve at the top of the tall, narrow part of the chamber B, in which the full charge volume extends down to the level *cc*. A number of exhaust valves E lead to a common exhaust outlet O, which may be fitted with a non-return valve, or each exhaust valve may carry a light non-return valve on its spindle, as shown. The level at which expansion reaches atmospheric pressures is, say, *ff*, but this level having been reached by the water, its further movement draws in fresh combustible mixture till it occupies the space down to *cc*, and the liquid level has fallen to *gg*. The column of liquid now returns and drives the exhaust products through the valves E—which had opened by their own weight—until these valves are shut by the water. The kinetic energy acquired by the column is now spent in compressing the fresh charge, which is ignited to start a new cycle. Thus, each outstroke is a working stroke, and no locking gear is required on the valves.

The same cycle applies to Fig. 5, but in this case there is a series of admission valves placed in a ring so as to allow the mixture to enter with a low velocity in order to prevent eddies and mixing with the exhaust products. A higher compression pressure is obtained with this pump than with the simple pump, and consequently higher efficiencies with the same lift.

Fig. 6 shows the arrangement of a double-barrel pump, which has two combustion chambers, A and B, in which explosion occurs alternately. Any Humphrey pump, whether single or double barrel, may be converted into a high-lift pump by means of an air-vessel fitted with valves, and called an "intensifier." The idea is to first allow the water-column to gain velocity, and then to utilize its kinetic energy to (a) compress an elastic fluid, and (b) deliver water under the pressure to which the elastic fluid has been compressed.

In Fig. 6, A and B are the barrels of a two-barrel pump, and at the end of the play-pipe D there are two air-vessels E and F, the latter being large enough to give a continuous flow at outlet O, and to maintain a practically uniform pressure. The smaller air-vessel E is fitted with a downwardly projecting pipe K, open to the atmosphere at the top, and carrying a valve L at its lower extremity, arranged to close under the action of the rising water. The cycle starts with explosion, all valves except L being shut, and the water level as shown. While the water level in E is rising to L, air is merely being discharged into the atmosphere, and as no work is being done by the column of water, it gains speed until valve L is shut by impact. Imprisoned in E there is now a definite quantity of air, which suffers compression until its pressure reaches that at which the high-pressure water-valves W can open, and allow the remaining kinetic energy of the column to force water into F. Valves W close when the column comes to rest, but there remains enough energy in the compressed air in E to give, by expansion, the return flow, which causes exhaust in A and compression of the fresh charge in B to start a fresh cycle. When the water level falls below valve L this valve opens, and air is admitted into E for the rest of the return stroke.

Now it is easy to see that if the pipe K is

made vertically adjustable with regard to E, the point of the cyle at which L shuts can be varied, and more or less air entrapped in E at will. But the amount of energy stored in this air will also vary with its quantity, for we assume that the degree of compression remains constant, and is indeed fixed by the pressure maintained in F. Consequently the ratio of the total energy of the working stroke to the energy stored in the compressed air in E can be made anything desired, or, in other words, we can obtain any compression pressure of the new charge in B which we like, and this independent of the water lift. The advantage is obvious, for compression pressures equal to those in modern gas-engines can be employed with a corresponding increase in thermal efficiency. Further, by manipulating the position of pipe K a given pump can be made to meet any conditions as to height of lift, for if the lift increases K can be raised, so that the energy stored in the air in E remains the same, there being now less air, but at a higher pressure.

An important development of the arrangement is shown in Fig. 6, and notice is directed to the fact that at each cycle air is drawn into, and rejected from the vessel E. Let us suppose K to be connected to a supply of combustible mixture instead of opening into the atmosphere, we shall then have an automatic pump for taking in mixture and discharging it under pressure. If the discharge is into a reservoir from which combustion chambers A and B can be supplied, we have at once a means of quickening the cycles and greatly increasing the output of a given size apparatus. It is convenient to replace vessel E by two vessels, one for air and one for gas, so as to maintain the combustible constituents separate until they enter the combustion-chambers. If the first portion of the out-stroke of the water column is allowed to reject the surplus air and gas back to the sources of supply, then the action throughout the cycle is precisely that described when using the single vessel E, except that a larger proportion of the total energy is absorbed in the compression of air and gas, but the excess is given out again during the expansion of the pre-compressed charge in either A or B. The chief advantage arises from the more rapid working, as there is no longer any need to wait for the water-level in A or B to fall under the action of gravity when the charge is being taken in. In fact, the apparatus becomes practically independent of the water-level on the supply side. The 1000-H.P. Humphrey pump now under construction in Germany will operate in the manner just described, the result being that the dimensions are very moderate, and the pump itself occupies no more space than a 1000-H.P. tandem gas-engine.

If the column of water oscillating in the play-pipe of a Humphrey pump is used as a water piston, and caused to rise and fall in an air vessel fitted with suitable valves for the inlet and outlet of air, the combination constitutes an air-compressor of a very efficient type and promising many advantages. Take the case of a single-barrel pump and a single air vessel, shown in Fig. 7. The cycle, which may take two seconds to accomplish, is as follows:

	Pump Chamber. A.	Air Compressor Chamber. C.
1st out-stroke.	Expansion to atmosphere. Intake of scavenging air.	Expulsion of air till water shuts valve *s*. Compression and discharge of compressed air till water shuts valve *g*. Cushion till water comes to rest.
1st in-stroke.	Exhaust till water shuts valve *e*. Cushion till water comes to rest.	Expansion of cushion to atmosphere. Intake of fresh air.
2nd out-stroke.	Expansion of cushion to atmosphere. Intake of combustible charge in excess.	Compression of air, but not sufficient for further delivery.
2nd in-stroke.	Rejection of surplus charge till water shuts valve *r*. Compression of charge till water comes to rest.	Expansion of compressed air.

The flexibility of the air-compressor can now be studied. To begin with the pump side, the level of the inlet valve *e*, and the rejected-charge *r*, are assumed to be variable, although Fig. 7, being merely a diagram, does not show how the pipes carrying these valves are moved vertically. As the level of these two valves controls the amount of charge ignited at each cycle, and the amount of the cushion space, their regulation is all that is required to increase or diminish the energy developed per working stroke. On the compressor side the position of the valves *g* and *s* controls the cycle of operations on this side of the apparatus, and renders it possible to compress a large volume of air to a low pressure, or a smaller volume of air to a high pressure, or to make any intermediate changes which may be desired.

Thus all the conditions of output, up to the full limit of the compressor, may be governed at will, and for all ranges the compression pressure of the new charge may be kept up to the required degree, so that the apparatus works at its maximum efficiency throughout the whole range. The amount of water which oscillates between the chambers should theoretically be altered along with the total capacity per working cycle, but the reason for this is merely to prevent the last portion of each down stroke from being wasted by taking in surplus combustible mixture in one chamber, or surplus air in the other chamber, to an undue extent. If the surplus of the combustible mixture is unnecessarily large, the extra amount rejected will increase the pressure in the reservoir X, and this increase of pressure may be made to automatically govern a water supply, and so bring up the total volume of reciprocating water, or to allow part of the water already in the apparatus to escape, so as just to keep a small amount of excess charge for each cycle, no matter what may be the output of the pump.

THE TURBOCOMPRESSOR

The turboblower and turbocompressor, is a suitable machine for exhausting or compressing large volumes of air or gas. Although only a short time ago it was usually considered to be impossible to make a commercially efficient and serviceable blower of this type for any but the lowest pressures, it is claimed that even at pressures as high as 150 pounds per square inch the new type of turbocompressor is at the very least equal in thermal and mechanical efficiency to the best kind of reciprocating air compressor, whilst from a commercial point of view, the turboblowers or compressors are often preferable on account of advantages attainable through their introduction. The following are some of these advantages:

1. The turboblowers and compressors deliver a steady (non-pulsating) current of air or gas.

2. They run practically without noise at all loads.

3. They are simple in construction, have all parts easily accessible, and are reliable in action.

4. They not only require very little attendance and lubrication when at work, but relatively speaking, a minimum of space for their accommodation.

5. They require a minimum of power to drive; they are also easily governed through a wide range of variation of speed, without materially affecting their economy.

6. They are perfectly balanced both dynamically and in respect of axial thrust.

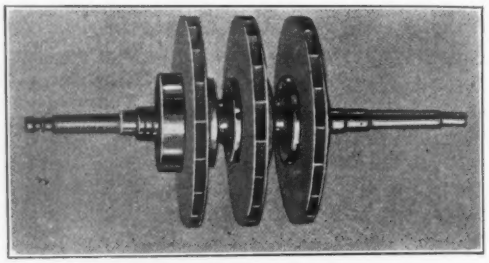


FIG. 1.

As already stated, turboblowers are adopted for a variety of purposes. It is possible they are preferable to reciprocating engines in all cases where the volume of the air or gas to be handled is sufficiently great, quite irrespective of whether they are required to produce a rise of pressure or a partial vacuum. The turbo compressor, in a like manner, is suitable for all pressures up to 120 pounds per square inch,

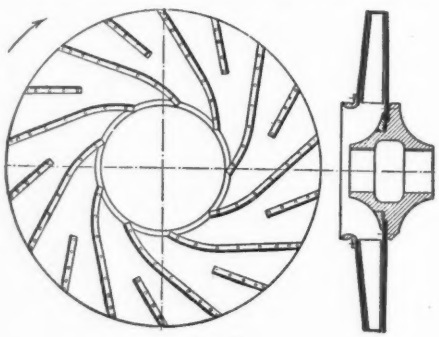


FIG. 2.

if the volume of gas or air to be handled is sufficiently large. Both the blowers and compressors are suited for direct coupling to steam turbines, but they may equally well be driven by electromotors of suitable size and speed.

The impeller shown in Fig. 1 is similar in design and detail, whether intended for a blower or for a compressor. To avoid the high stresses to which it is subjected the im-

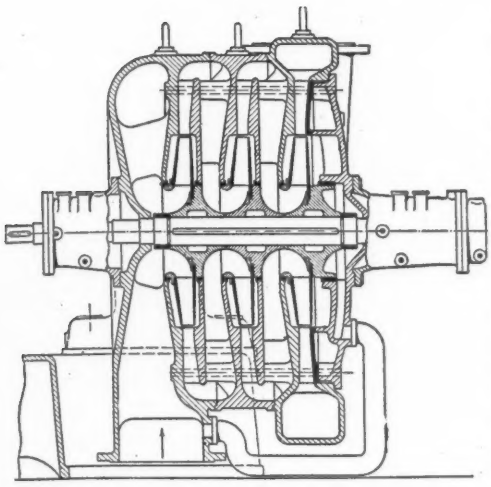


FIG. 3.

end and intermediate parts of the casing overhang the bedplate, but are well connected to the inlet cover by vertical, cylindrical, spigot, and faucet joints. The general design is such that all parts of the blower are easily reached for examination or adjustment.

In the case of the turbocompressors, the same general principles of design are followed. As, however, a compressor is usually of considerably greater length than a blower, the two bearings of the former, situated one at each end of the machine, are designed to support the casing as well as the rotor at both ends. Here, too, on account of the greater length of the unit, although the vertical divisions of the casing are maintained, a further horizontal division is introduced, as shown in Fig. 4, so that, after removing the upper

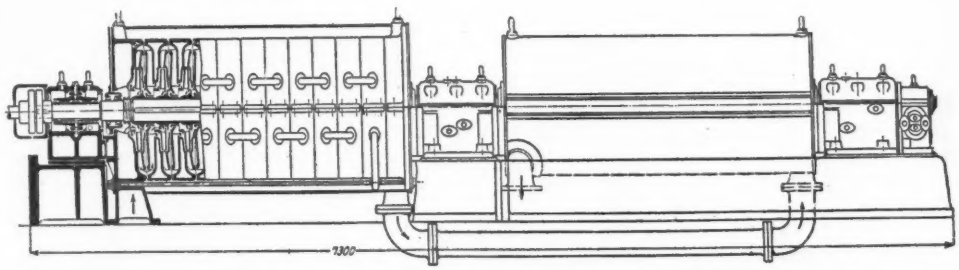


FIG. 4. SECTIONAL ELEVATION OF FIVE CYLINDER TURBOCOMPRESSOR.

peller is built up of those materials which are most suitable for the various parts of the wheel. Thus, the bosses are steel castings, whilst the cheeks are of special steel plates. The latter, as shown in Fig. 2, are conical in cross-section, and attached to the boss in such a manner as to allow free expansion of both cheeks under the influence of centrifugal force. As a result of this construction, the impeller runs true and steady at all speeds, and permits of the running clearances being reduced to a minimum, with the result that internal circulating losses are small.

The housings of these turboblowers and compressors are respectively designed to suit the requirements of the two types of machine. In both cases the housing is fixed at one (the driving) end only, and is free to move with variations of temperature at the other.

In the turboblower shown in Fig. 3 the inlet cover is provided with substantial feet solidly connected to the bedplate. The pressure half of the housing, each impeller and its corresponding part of the casing are freely accessible for inspection.

The ease with which air may be cooled whilst being compressed in a turbocompressor is to no small extent answerable for the good efficiency of the unit. When reciprocating engines are employed, the effect of water-jackets decreases as the cylinder volume increases; for which reason, if low final temperatures are to be obtained, multistage compressors must be resorted to and intermediate coolers employed. In the case of turbo machinery, the form of the housing and the condition in which the air or gas passes through the machine are both favorable to the efficient use of water-jackets. The rise of temperature can therefore be reduced to a minimum.

The easy and economical method of regulating the delivery and pressure of these blowers compares favorably with the methods—such as by-pass mains and variable clearance volumes, etc.—necessary with some types of

blowing machinery. Delivery volume, pressure, and rotary speed vary, as is the case with centrifugal pumps, in fixed proportion to one another; consequently, delivery volume and pressure may be changed by simply varying the rotary speed. At constant speed, volume and pressure may be varied by adjusting the regulating valve usually situated in the suction main. By this means the delivery volume may be varied between its maximum value and zero, the power consumed falling with the reduction of volume, while the efficiency,

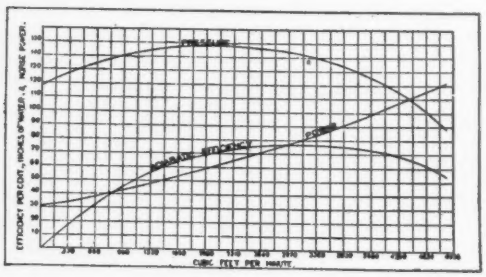


FIG. 5.

as shown in the curve, Fig. 5, is but slightly affected, even by comparatively large changes of volume.

If turbocompressors are directly coupled to steam turbines, a pressure-regulating device can be made to govern the speed of the turbine in such a way as to maintain a constant air or gas pressure in spite of variations of delivered volume. The high efficiency already obtained (78 per cent.) as referred to adiabatic compression, places these turboblowers very favorably in comparison with the best reciprocating blowing engines.

An apparatus known as a solar smelter has been erected outside Johannesburg in South Africa, whose object is to smelt copper, tin, iron, etc., direct out of the ore by means of the heat from a reflector and, in the case of precious metals, even vaporizing them out of the gangue and condensing the vapor The apparatus may also be used in the manufacture of calcium carbide and certain nitrates and in the distillation of oils. Curved mirrors of parabolic cross-section are mounted upon a frame comprising bars, rigidly connected together and to an underframe which is adapted to run upon the wheels around a circular track to allow for the apparent movement of the sun

TOP HEADING AND BOTTOM HEADING METHOD OF ATTACK IN TUNNEL CONSTRUCTION

The method of tunnel construction known as the "top heading and bench" method is in almost universal use in the United States. The reason assigned for this, or rather the general understanding in regard to it, is that this method is both cheaper and safer than any other method of attack.

Throughout Europe the "bottom heading" method of attack in some one of its forms is employed almost universally. European engineers are convinced of the superiority of this method over the "top heading and bench" method employed in America. It may be said, however, that the most convincing arguments in support of the superiority of the European practice are based on the necessity for dealing with the tremendous rock pressures encountered in parts of Europe, and particularly in the Alps, a condition that does not prevail in this country.

ROCK PRESSURES.

These rock pressures are an interesting phenomenon. They make necessary the employment of careful methods of excavation, of timbering, and of lining. In tunnel construction in this country timbering is often necessary to prevent rock falls, which are apparently due to the weight of rock masses that are insecurely attached to the adjacent mountain masses. In the Alps, on the contrary, the phenomenon is one of actual pressure from all sides, a pressure tending to crush in the roofs and sides of a tunnel and to raise the floors. These pressures are not due to a disintegration of the rock masses with consequent tendency to displacement, but are apparently caused by forces imprisoned, we might say, in the formation of the mountains. Experience has shown that these forces are ultimately exhausted in so far as they affect any individual tunnel. This is indicated in the case of the Karawanken tunnel, where the rock pressures, which were of unusual intensity during the early stages of construction, have greatly diminished and now show signs of ceasing entirely. It is evident that a method rendered necessary by such conditions might be highly uneconomical where, as in America, these condition do not exist.

BOTTOM HEADING ADVANTAGES.

With reference to economical considerations it is claimed as an advantage of the "bottom

heading" method that all the different working operations in connection with the construction of the tunnel, such as driving the bottom heading and the top heading, excavating the full section and lining the tunnel, are confined to one track which is extended as fast as the bottom heading is driven and remains in one position until construction is completed. At the same time the bottom heading drains the whole tunnel section, and inflowing water is led away in the bottom of the tunnel. Comparison is here made with the straight "top heading" method, in which the top heading is driven complete, and the full section is afterwards excavated. It may be said that this method is only used in tunnels of large size where the adjustment of spoils removal to rate of advance introduces an economic question of more importance than the maintenance of a track in one position. The argument has little force against the "top heading and bench" method, especially where the excavation of the full section follows closely behind the heading, since conditions as to track and drainage are practically the same in the two cases. It therefore appears that the superiority of the bottom heading method is confined to cases where rock pressures exist.

AUSTRIAN METHOD.

The method employed in the construction of the long series of tunnels [see full description in *Engineering-Contracting*, Jan. 4] on what is known as the Second Railway to Trieste, in the Austrian Alps, was, with one exception, what is known as the "Austrian" method which, briefly, is as follows: A bottom heading is driven as an advance heading. Shafts are then excavated from this heading to the top of the tunnel arch. The top heading is then driven, all spoils being dumped through the shafts already excavated, and removed through the bottom heading. The full section is then excavated and lined in detached lengths of from 25 to 35 ft. Finally the intermediate sections are excavated and lined. It will be seen that this process has in view at every stage the resistance to rock pressure, great care being taken not to have too much unlined excavation open at any one time.

A variation of the above method is what is known as the "Belgian" method. In this method the top and bottom headings are driven and shafts excavated in the order as given above. Instead, however, of excavating and lining the whole tunnel section, excavation is first made in short lengths for the arch ring alone, and the arch is built, resting on the rock at the level of the springing line. After this is completed the full section is excavated and side walls built under the arches. It will be observed that in this process the greatest precaution is taken against damage from rock pressure, since the arch is put in at the earliest possible stage.

KARAWANKEN TUNNEL.

In the Karawanken tunnel a top heading was driven independently of the bottom heading. This was done because of the presence of fire damp in large quantities, which interfered greatly with the construction of this tunnel. It was not considered safe to excavate shafts from the bottom heading to the arch as was done in the other tunnels, as it was feared that they would serve as pockets for collecting this light gas. The most intense pressures were here encountered, extending over a length of more than a mile. The high cost per foot of this tunnel ($284 per lin. ft.) is doubtless due to the trouble caused by rock pressures, the frequent collapse of timbering and completed lining, and the many interruptions due to inbursts of water. So great were the pressures in this tunnel that the layer of rock, 13 ft. in thickness, lying between the top and bottom headings, was seriously distorted in many places, and heavy bracing was installed to prevent the total collapse of the tunnel.

In a bulletin of the International Railway Congress Association, Mr. F. Hennings, professor of engineering at the Zurick Polytechnic School, advocates the top-cut or high-heading method in the construction of Alpine Tunnels. This was the method used successfully by Rziha in constructing the Czernitz tunnel, where also great pressure was encountered. In this method a bottom heading is first driven, and is then extended upward in two layers to the tunnel arch. The semicircle of the arch is then excavated in segments, bracing by means of crown bars following the excavation closely. This process is then continued downward, the walls of the bottom heading being the last material excavated.

In the methods outlined above the controll-

ing factor is resistance to rock pressure, safety at each stage of the process being carefully provided for. Where rock pressures do not exist, it would seem far more economical to use the "top heading and bench" method as employed in this country.—*Slightly abridged from editorial in Engineering-Contracting.*

LOFTY COOKING

Housewives in the Rocky Mountain region and in other elevated portions of the United States are obliged to solve a few culinary problems that do not trouble women elsewhere.

For example, a woman goes from an Eastern city to live in one of the high valleys of Colorado. She attempts to make a cake and quite naturally uses the recipe to which she has long been accustomed. The cake, instead of acting as it ought, flows over the side of the pan, covers the bottom of the oven and tries to find its way out under the oven door and over the kitchen floor. What remains in the pan, instead of rounding up, appears collapsed.

The trouble is not with the recipe but with the atmospheric pressure, which interferes with cooking in a good many ways. At sea-level, water boils at 212° Fahrenheit. At an elevation of ten hundred and twenty feet it boils at 210°. At Denver, which is one mile above sea-level, water boils at 202°. In the San Luis Valley, at Del Norte, which is seventy-seven hundred and fifty feet up, it boils at 197°. At Leadville, which is nearly two miles above the sea, it boils at 193°.

How is the housewife to boil an egg at Leadville? The answer is that the thing is very hard to accomplish. At all events, she must cook the egg some minutes longer than the time customary in New York or Chicago. It is not the fact of boiling that cooks an egg, but the number of units of temperature employed in the process; hence it takes a good deal longer to cook it at 193° than to bring it to the requisite point of "doneness" in a surrounding fluid medium of 212°.

The trouble with the cake previously mentioned was that the gas generated in it by the baking powder was too strong for it. At sea-level there would have been no trouble, because the pressure of the air on the outside would have been a sufficient restraint; but, the pressure up in the mountains of Colorado being so much less, the gas in the cake made bigger bubbles which tended to run together, until the remaining walls were not sufficient to sustain the weight. Then the cake fell, the pent-up gas escaping through fissures in its outer layer. Incidentally to the process, the gas, insufficiently restrained, caused most of the material of the cake to overflow the sides of the pan.

One naturally asks, What should a woman do under such circumstances? It is very simple. She should either use less baking powder or increase the tenacity of her dough by contributing more albumen in the shape of an additional egg.

COMPRESSED AIR LOCOMOTIVES FOR COAL MINES*

In 1895 the first compressed air locomotive was installed in the anthracite region in the No. 6 colliery of the Susquehanna Coal Co., near Wilkesbarre. Since then this type of locomotive has come into quite general use, due to its simplicity and its rugged characteristics which make it possible to operate it with unskilled men, through wet gangways and under bad roof, and also because it was, and is, the only practical and proven independent locomotive which will operate without fire, smoke, sparks or wires. Today there are about two hundred and seventy-five compressed air locomotives at work in the coal mines of Pennsylvania alone, and about as many more in other States and Canada.

In the past it is the locomotive which has been used when no other would do the work.

If there is gas the air locomotive cannot ignite it.

If there is bad roof, there is nothing essential to the system which will be injured by an ordinary fall.

If the mine is wet, it does no harm except to make the locomotive dirty.

If the bottom heaves, if the track is bad and curves are sharp and derailments frequent, the air locomotive is seldom injured, and its own power is available to assist in cleaning up the wreck to which any other type of locomotive might have set fire.

The features which limited its use to those mines where one or more of the above condi-

*From a paper by C. B. Hodges, before the West Virginia Coal Mining Institute.

tions rendered this locomotive particularly desirable are:

Long tanks to contain a sufficient supply of compressed air, which required more room on curves, and the first cost of the compressors, boilers, pipe lines and charging stations required to supply them with a sufficient quantity of compressed air at convenient points.

Briefly, the essential features of a complete installation of compressed air locomotives are:

1—One or more compressed air locomotives having sufficient tractive force and weight to handle trains of the most economical size and tanks to contain air for the longest possible runs without exceeding the limits of height, width and length which can be economically obtained.

2—One or more air compressors of sufficient capacity to at all times supply the locomotives with sufficient air.

3—One or more charging stations so located that the locomotives will seldom, if ever, be compelled to do special running in order to obtained compressed air as required.

4—A stationary storage system (usually a pipe line) having sufficient volume to equalize the variable rates at which the locomotives may charge, which, taken in connection with the compressors, will insure a satisfactory charge of air for the locomotives whenever they may come to a charging station, and will at the same time provide for connecting up the various charging stations with the compressors.

5—All parts must be combined to form a satisfactory working plant as a whole, and each detail must be carefully worked out to insure sufficient strength to safely sustain the high pressures employed, and also to insure satisfactory operation.

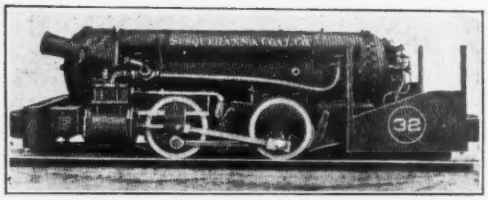
Compressors used to supply air for mine locomotives ordinarily deliver the air to the pipe line at a pressure of 1000 pounds per square inch. This pressure is obtained by compressing in either three or four stages. To compress 100 cubic feet of free air per minute to 1000 pounds pressure in three stages requires about thirty-four horse power; in four stages, thirty-two horse power.

As in even the latest type of compressed air locomotive the air pressure is reduced from 1000 pounds to 250 pounds before the air begins to do any work in the cylinders, there is apparently a very great loss in sufficiently compressing the air to enable a locomotive to make reasonably long runs on one charge. This loss, however, is not so great as the difference of pressure would indicate. To compress 100 cubic feet of air per minute to 250 pounds in two stages requires twenty-three horse power, so that it only requires about ten more horsepower to raise the pressure from 250 to 1,000 pounds or considerably less than one-half additional power to give four times the gage pressure. The reason for this is apparent when the operation of the three-stage compressor is considered.

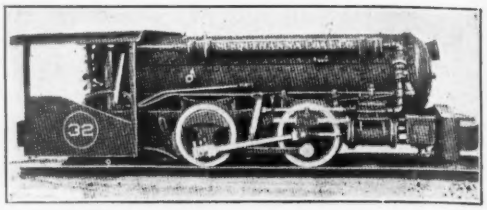
In the first stage the air is compressed to about one-fourth of its volume and to four times its pressure, making the pressure in the first inter-cooler 60 pounds absolute or 45 pounds gauge. In the second stage the volume is again reduced to one-fourth and the pressure increased four times, making the pressure in the second inter-cooler 240 pounds absolute or 225 pounds gauge. In the last cylinder the air is again condensed to one-fourth of its volume and the pressure raised to about 1,000 pounds. In the first stage the volume of the compressing cylinder will be sixteen times that of the high-pressure cylinder and four times that of the intermediate cylinder, and in each case the average pressures are reversely as the volume, so that the total work in each stage is approximately the same.

The three or four-stage compressors as built to-day for producing pressures of from 1,000 to 1,500 pounds are as reliable and satisfactory as machines as are the compressors for 90 pounds which are so widely distributed throughout the mining and industrial world. The high-pressure compressors are provided with speed and pressure governors which will prevent racing under all conditions of service and which will slow down the compressor as the maximum pressure desired is approached and if further reduction in the supply is required, will completely unload or come to a dead stop, if desired. so that no more attention is required for them than should ordinarily be given to a piece of mechanism in continuous motion.

The pipe lines are almost exclusively made from a special quality of wrought iron pipe with extra heavy counterbored sockets for coupling. Each pipe is tested to 1,800 pounds, for a working pressure of 1,000 pounds, and



LEFT HAND SIDE.



RIGHT HAND SIDE.

the ultimate bursting pressure of the pipe varies from 3,500 to 5,000 pounds. In order to provide for access to any joint in the pipe flanged couplings are introduced at intervals of from 200 to 400 feet.

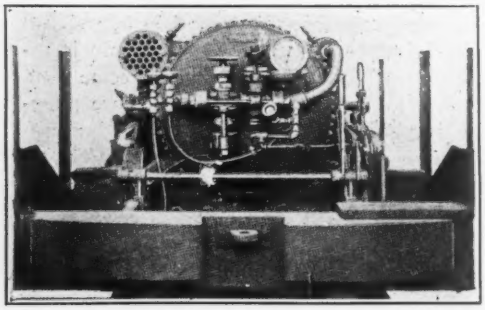
With pipe lines of this character carrying air at 1,000 pounds pressure, the loss due to leakage is practically negligible, and the labor and expense required in maintaining them in this condition is no greater than that required for air lines containing air at 90 pounds pressure, and less than is required to keep a steam line in good condition.

The charging stations consist of a tee in the pipe line or elbow on the end of it, to which is attached a specially designed stop valve with a flexible metallic coupling, which provides sufficient latitude to avoid the delays incident to stopping the locomotive with too great accuracy. With this device the locomotives are ordinarily charged in about one and one-half minutes.

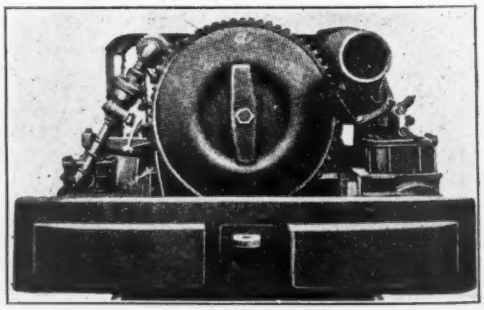
Until 1908 the locomotives were built along substantially the same lines as steam locomotives. The only difference was that one or more heavy steel tanks were substituted for the boiler, and a reducing valve was introduced to maintain a pressure of about 150 pounds at the throttle valve.

In 1908 a new type of compressed air locomotive was offered and has been sold and installed, to the practical exclusion of the older type of single-expansion compressed air locomotive, during the past two years. The first locomotive of this type was built by the H. K. Porter Company and installed in a mine of the Susquehanna Coal Company at Nanticoke, Pennsylvania. Before many tests were made the men running it reported that "it was saving lots of air," and later, comparative tests made by hauling the same cars the same distance over the same piece of track, alternately with the two-stage and then with a single-expansion locomotive of equal capacity, demonstrated that for six separate trips, with variable loads, the average air consumption of the two-stage was fifty-six per cent. of that of the single-expansion locomotive. The increased efficiency was obtained by expanding the compressed air in two successive cylinders, in connection with simply atmospheric interheating during the process of expansion.

This locomotive is shown in four views. The air is stored, at a pressure of eight or nine hundred pounds, in the large cylindrical reservoir, which may be re-charged in one or two minutes from a stationary storage. The air reaches the high-pressure cylinder through a regulating valve, at 250 pounds pressure and atmospheric temperature. From this cylinder it exhausts through an atmospheric interheater, at a pressure of 50 pounds, to the low pressure cylinder.

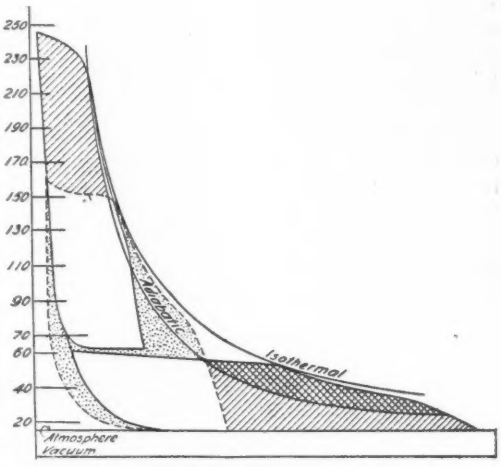


FRONT END.



REAR END.

On account of the work done in the high-pressure cylinder (about 20,000 foot-pounds per pound of air), the temperature of the air leaving the high-pressure cylinder is about 140 degrees, Fahrenheit, below that of the atmosphere, rendering the surrounding air an efficient heating medium, which may be readily utilized by means of the inter-heating cylindrical reservoir filled with small tubes, through which the atmospheric air is rapidly drawn by the ejector action of the exhaust from the low-pressure cylinder. In this apparatus nearly all of the heat lost in the high pressure cylinder is restored, expanding the air about thirty-six per cent. and permitting higher initial and lower terminal pressures, with a wider range of expansion—the essential features of economical operation, practically impossible in connection with the single-expansion locomotive, on account of unmanageable refrigeration.



COMBINED INDICATOR DIAGRAMS.

Since the first locomotive of this type was built, about one hundred more have been put in operation in mines, lumber yards and other industrial establishments. Many of these installations were possible only with the new type of locomotive, as with the older type of single-expansion locomotive, the cost of the compressors, boilers and pipe lines would have been too great; or the cost of the power to operate the compressors would have been too high; or the locomotives would have had to be charged too frequently.

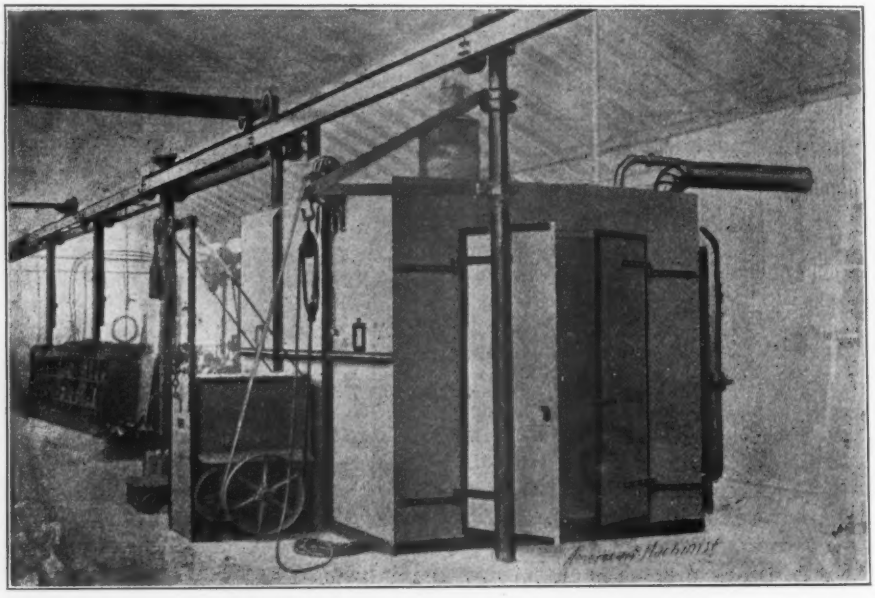
The increased efficiency obtained with this type of locomotive has resulted, under ordinary conditions, in reducing the cost of power about 30 per cent., reducing the size of the compressors and boilers thirty per cent., reducing the first cost of the complete installation approximately fifteen per cent., and increased by thirty per cent. the distance which the locomotive will travel on one charge of air.

The combined indicator diagrams show by their area the relative quantities of work obtained from the same amount of compressed air. The area inside of the dotted lines indicates the amount of work obtained from a given quantity of compressed air in the single-expansion locomotive; the area inside of the two indicator diagrams shown in solid lines, the amount of work obtained from the same quantity of air in the new type of two-stage locomotive. The single cross-hatched area is the gain due to a wider range of expansion with a higher initial and lower terminal pressure, possible only in connection with the atmospheric inter-heater which prevents unmanageable refrigeration and incidentally adds about eighteen per cent. to the total quantity of work done by the air by expanding it in the process of re-heating to a sufficient extent to increase the area of the low-pressure card by the quantity indicated by the double cross-hatched area. The stippled area indicates the losses due to the impossibility of always haivng the valve gear of the two cylinders exactly adjusted to obtain the most economical results.

The durability of the pipe lines under mining conditions is a feature of compressed air haulage which at times has been questioned. The life of wrought iron pipe in a mine will of course, vary with local conditions. As a matter of experience, pipe lines were installed in the shaft and gangways of the colliery of the Susquehanna Coal Company at Glen Lyon, Pennsylvania, in 1895, and are still conveying the air to the charging stations for the operation of the locomotives. The same is true of pipe lines installed in the Rolling Mill Mines of the Cambria Steel Company, at Johnstown, Pennsylvania. These lines were installed in 1898. Still another case is that of the Carbon Mine of the Keystone Coal & Coke Co., where pipe was installed in the Gangways in 1897 and is still a part of the piping system which furnishes air to eight compressed air locomotives for the Carbon and

Greensburg No. 2 Mines which jointly receive a supply from the central compressing plant. These instances are merely representative cases of which the writer has definite and recent knowledge.

While having been more or less intimately connected with the subject of compressed air haulage in general throughout the United States and Canada for the past fifteen years, I have known of but one case of replacing a pipe line on account of deterioration due to rusting, acids or any other cause.



A SHOT BLAST TUMBLER INSTALLATION.

THE BEGINNINGS OF SUGAR

It almost gives one a fit of melancholy to sit down and try to picture to himself the alarming state of affairs which must have existed in the good old days when Rome was mistress of the world, and the art and culture of Greece were civilizing her mistress and there was no sugar. Of course there was honey, but what of honey in comparison with the possibilities of sugar? Think of a toddy without sugar, and imagine if you can what a milk punch sweetened with honey would taste like. Your heart almost bleeds for laughing at jovial old Horace as you picture him to yourself sitting under his own vine and fig tree among a small company of the brilliant lights of those palmy days, ladling out his old Falernian punch, sugarless and lemonless, while the thought of old Diogenes lolling in his tub without so much as a penny stick of peppermint to tickle his philosophical palate, and the valorous Anthony paying court to the divine coquette of Egypt without the customary bonbons makes you murmur in mournful numbers: "Was life worth living then, anyhow?" And yet such was the case in those days and all days up to the middle of the middle ages, although the exact date of the invention of sugar hides itself in the dim uncertain regions of myth and legend.

SHOT-BLAST TUMBLING BARRELS

The Mathewson sand blast rattler appliances supplied by the Tilghman Patent Sand Blast Company, Ltd., Broadheath, near Manchester, England, have been employed for the cleaning of castings, etc., for some little time. They are intended for comparatively small castings, larger pieces than, say, 50 pounds weight, being dealt with in the sand-blast room. It is not a sand blast that is used, small chilled-iron shot from 1-40 inch to 1-60 inch diameter being employed.

Fig. 1, which illustrates a barrel plant at the side of a sand-blast room in the works of the Tilghman Company, shows a rattler driven by belt off an overhead motor. The blast itself is taken into one or both ends of the barrel and this is about half filled with castings.

With the rotation of the barrel the castings are regularly turned over, presenting new surfaces to the action of the air-propelled shot. As the barrel moves quite slowly, two to four turns a minute being made, even light castings are not broken by the action. The castings are fed into the barrel through a sliding door and perforations allow the dust and shot, etc., to escape through a hopper so as to meet a current of air. This drives the lighter sand

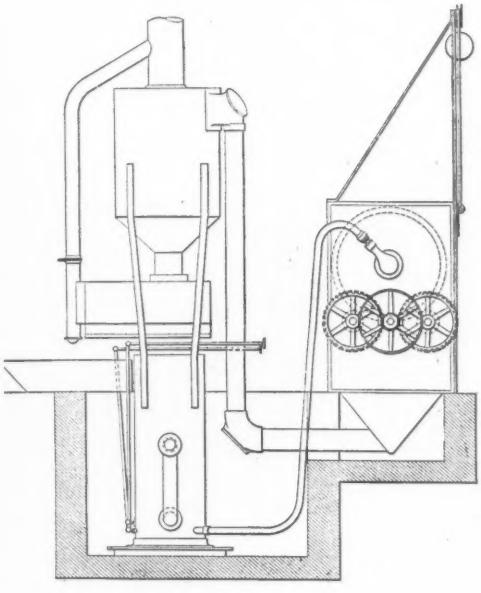


FIG. 2.

away, while the shot falls into a hopper ready for use again.

Fig. 2 illustrates the outfit with sand elevator, separator and air sieve. An exhauster, not shown, maintains a partial vacuum (about 3½ inches water gage) in the tumbling barrel so that any leakage is inward. The sand, etc., is thus drawn to the separator. Shot is used because it does not break up so readily as sand and therefore causes less dust. The castings may be cleaned right down to the metal and a considerable saving in machining cost can readily be claimed.

The plant is built in a number of sizes and continuous tumbling barrels also are supplied, the castings being fed in at one end and passing out at the other after being subjected to the action of four or more separate shot blasts, according to the length of the barrel.

Actual figures are given showing that this process is not only more thorough and efficient but also cheaper than hand work.

THE AIR SUPPLY.

The makers recommend a large volume at low pressure. The reason will be found in the air velocities corresponding to the different pressures. The work done, of course, depends on the velocity of the shot, and short pipes are used. Now, to make a comparison, through a pipe say three diameters long, the velocity at 10 pounds pressure is about 535 feet, a second; at 14.7 pounds, 634 feet; at 29.4 pounds, 656 feet; and at 73.5 pounds only 658 feet. The figures are taken from a well known textbook. It will be plain that after about 15 pounds pressure the velocity rises very slowly. Obviously loss in pressure reduction, from high to low, should be avoided. The firm, therefore, recommend from 5 to 25 or 30 pounds per square inch as a suitable pressure for the air supply. Condensed from *American Machinist.*

AUTOMATIC STABILITY OF A BIPLANE

Lieut. J. W. Dunne recently gave an exhibition of his automatic stability biplane at the Royal Aero Club's flying ground in the Isle of Shippey close to the Thames estuary, Orville Wright being an interested spectator.

Lieut. Dunne made two flights of seven and eight miles, and the interest of the performance lay in the fact that the aviator was able as he flew to take his hands off the control levers and to write notes, which he showed to Mr. Wright in proof of his claim that he has solved the problem of automatic stability.

Lieut. Dunne's machine is a fairly heavy one and is shaped much like a snow plough with the sides open. It has neither tail nor rudder and depends for its steering power on two small flaps at the rear edge of the upper planes. With these the airman brings his machine around to the right or left with perfect ease, keeping at the same time on an even keel.

Aid to air pilots is to be offered by the Blue Hill Observatory, outside of Boston. Experts there are at work on a series of air-current charts, the material for which has been accumulating at the observatory for years.

LOSS OF HEAD IN TRANSMISSION THROUGH PIPES.

1-INCH PIPE.

Initial Pressure, 75 Pounds, Gage.						Initial Pressure, 90 Pounds, Gage.						Initial Pressure, 105 Pounds, Gage.					
Free Air per Minute, Cubic Feet.	Flow in Pipe per Minute, Feet.	Length of Pipe in Feet.				Free Air per Minute, Cubic Feet.	Flow in Pipe per Minute, Feet.	Length of Pipe in Feet.				Free Air per Minute, Cubic Feet.	Flow in Pipe per Minute, Feet.	Length of Pipe in Feet.			
		100	200	300	400			100	200	300	400			100	200	300	400
12.5	385	0.05	0.09	0.13	0.17	12.5	330	0.04	0 08	0 11	0 15	12.5	289	0.03	0.08	0.10	0.13
25	771	0.18	0.35	0.53	0.70	25	661	0.15	0.30	0.45	0 59	25	578	0.12	0.25	0.40	0.52
50	1543	0 69	1.40	2.11	2.83	50	1322	0.59	1.19	1 81	2 41	50	1157	0.52	1.05	1.56	2.10
75	2314	1.58	3.18	4 82	6 49	75	1984	1.35	2.72	4 10	5.51	75	1736	1.10	2.25	3.40	4.68
100	3086	2.82	5.74	8.76	11.89	100	2645	2.41	4.88	7.41	10.00	100	2313	2.11	4.25	6.42	8.65

1½-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		250	500	750	1000			250	500	750	1000			250	500	750	1000
25	339	0.06	0.12	0.18	0.23	25	291	0.05	0.10	0.15	0.20	25	254	0.04	0.08	0.12	0.17
50	679	0.23	0.46	0.69	0.92	50	582	0 19	0.39	0.59	0.79	50	510	0.17	0.33	0.50	0.68
100	1358	0.92	1.85	2 79	3.74	100	1164	0.79	1.58	2.38	3 18	100	1019	0.69	1.38	2.07	2.76
150	2037	2.08	4.22	6 39	8.64	150	1746	1.78	3.59	5.43	7.30	150	1528	1.53	3.14	4.65	6.32
200	2716	3.74	7.64	11.73	16.06	200	2328	3.18	6.47	9.87	13.39	200	2037	2.76	5.55	8.51	11.54

2-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet						Length of Pipe in Feet.			
		200	500	1000	2000			200	500	1000	2000			200	500	1000	2000
100	764	0.17	0.43	0.87	1.75	100	655	0.15	0.37	0.75	1.50	100	573	0.13	0.32	0.65	1.30
150	1146	0.39	0.98	1.97	3.99	150	982	0.34	0.83	1.69	3 40	150	859	0.29	0.74	1.47	2.95
200	1528	0.69	1.75	3.54	7.24	200	1310	0.59	1.51	3.02	6.48	200	1146	0.53	1.32	2.64	5 28
250	1910	1.09	2.31	5.60	11.60	250	1637	0.93	1.97	4.76	9.75	250	1433	0.83	2.09	4.17	8.35
300	2292	1.57	4.92	8.18	17.28	300	1965	1.35	3.45	6.92	14.37	300	1719	1.22	3.06	6.13	12.25

COMPRESSED AIR TRANSMISSION TABLES*

BY FRANK RICHARDS.

The accompanying tables of pressure losses during the flow of compressed air through pipes were computed by what may be termed the Rix-Johnson formula. J. E. Johnson, Jr., gave Church's familiar formula in a simplified form in the *American Machinist*, July 27, 1899, which was, in substance, as follows:

$$R=\frac{K\ V^2 L}{D^5}$$

where

V=Volume of free air in cubic feet per minute;

L=Length of pipe in feet;

D=Diameter of pipe in inches;

K=A numerical constant, which Johnson fixed as 0.0006;

R=Difference between the squares of the initial and terminal absolute pressures in pounds per square inch; that is, $p^2_1-p^2_2$.

I have reason to believe that this formula is now used in this country more generally than any other in practical compressed-air work.

E. A. Rix, of San Francisco, uses Johnson's formula with 0.0005 for the value of K. In my own practice I have found it more convenient to use the reciprocal of this value of K, that is, 2000, and transfer it to the divisor, where in actual numerical operations it almost invariably disappears at once by cancellation. I also find it more convenient for my pencil habit to use small letters instead of capitals; hence my working formula takes the form,

$$p^2_1-p^2_2=\frac{v^2\ l}{2000\ d^5}$$

This, of course, may be transformed to suit the special requirements, as:

$$l=\frac{2000\ d^5\ (p^2_1-p^2_2)}{v^2}$$

$$v=\sqrt{\frac{2000\ d^5\ (p^2_1-p^2_2)}{l}}$$

$$d^5=\frac{v^2\ l}{2000\ (p^2_1-p^2_2)}$$

Computations in this line do not invite, not hardly permit, micrometrical precision, and refinements are out of place; hence it is quite permissible and very convenient to use 15 pounds for the normal atmospheric pressure, and this has been done in computing the tables herein given. A single example of the process will suffice.

Let there be 5000 feet of 8-inch pipe, through which it is desired to transmit 4000 cubic feet of free air per minute at an initial pressure of

*Copyright, 1910, by Frank Richards.

LOSS OF HEAD IN TRANSMISSION THROUGH PIPES.

2½-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet						Length of Pipe in Feet			
		1000	1500	2000	2500			1000	1500	2000	2500			1000	1500	2000	2500
100	489	0 29	0 44	0 59	0 73	100	419	0 25	0 38	0 51	0 62	100	367	0 22	0 32	0 43	0 55
200	978	1 16	1 74	2 32	2 89	200	838	0 98	1 47	1 96	2 47	200	734	0 86	1 29	1 73	2 15
300	1467	2 6	3 91	5 25	6 64	300	1257	2 22	3 34	4 45	5 64	300	1100	1 94	2 88	3 87	4 95
400	1956	4 64	6 96	9 30	12 20	400	1676	3 98	6 00	8 00	10 25	400	1467	3 45	5 18	7 00	8 86
500	2450	7 50	10 00	15 10	18 90	500	2100	6 25	9 38	12 56	15 72	500	1838	5 45	8 20	11 15	14 17

3-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet			
		1000	1500	2000	2500			1000	1500	2000	2500			1000	1500	2000	2500
100	339	0 12	0 17	0 23	0 29	100	291	0 10	0 15	0 20	0 25	100	254	0 09	0 13	0 17	0 22
200	679	0 46	0 69	0 92	1 15	200	582	0 39	0 59	0 79	0 99	200	509	0 35	0 53	0 69	0 87
400	1358	1 86	2 79	3 75	4 69	400	1164	1 58	2 39	3 19	3 99	400	1019	1 41	2 12	2 76	3 48
600	2037	4 21	6 39	8 65	10 81	600	1746	3 59	5 43	7 31	9 14	600	1528	3 13	4 83	6 48	8 16
800	2716	7 64	11 74	16 11	20 15	800	2328	6 47	9 87	13 43	16 79	800	2037	5 74	8 72	11 78	14 65

4-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		1000	1500	2000	2500			1000	1500	2000	2500			1000	1500	2000	2500
250	477	0 17	0 26	0 34	0 43	250	409	0 15	0 24	0 29	0 37	250	358	0 12	0 19	0 26	0 32
500	955	0 68	1 02	1 37	1 71	500	818	0 58	0 82	1 17	1 47	500	716	0 51	0 76	1 02	1 28
750	1432	1 54	2 32	3 10	3 89	750	1227	1 31	1 98	2 65	3 32	750	1074	1 15	1 73	2 31	2 89
1000	1910	2 76	4 17	5 60	7 06	1000	1637	2 35	3 55	4 76	3 98	1000	1433	2 05	3 09	4 14	5 20
1250	2387	4 34	6 52	8 91	11 29	1250	2046	3 49	5 59	7 53	9 51	1250	1790	3 22	4 86	6 53	8 22

6-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		1000	2500	5000	10,000			1000	2500	5000	10,000			1000	2500	5000	10,000
1000	849	0.36	0.89	1.81	3.65	1000	727	0.31	0.77	1.54	3.10	1000	637	0.27	0.67	1 34	2.70
1500	1273	0.81	2.04	4.12	8.46	1500	1091	0.63	1.74	3.51	7.15	1500	955	0.61	1.51	3 04	6.16
2000	1698	1 44	3.64	7.45	15.64	2000	1454	1.23	3.10	6.31	13.05	2000	1274	1 08	2.70	5.46	11.19
2500	2122	2.26	5.75	11.93	26.14	2500	1817	1.93	4.89	10.07	21.25	2500	1591	1 69	4.27	8.69	18.12
3000	2547	3.28	8.45	17.86		3000	2181	2.79	7.14	14.84		3000	1910	2 43	6 6	14.55	27.05

8-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		1000	2500	5000	10,000			1000	2500	5000	10,000			1000	2500	5000	10,000
2000	954	0.34	0.85	1.71	3.46	2000	818	0.29	0.73	1.47	2.95	2000	716	0.26	0 64	1.28	2.57
3000	1432	0 77	1.92	3.89	7.97	3000	1227	0.66	1.64	3.32	6.75	3000	1074	0.57	1.44	2 90	5.87
4000	1909	1.37	3.46	7.06	14.77	4000	1636	1.17	2.95	5.98	12.35	4000	1432	1.02	2.57	5.20	10.65
5000	2386	2.15	5.46	11.29	24.51	5000	2045	1.83	4.64	9.51	20.06	5000	1790	1.60	4.04	8.23	17.61
6000	2864	3 10	7.98	16.83		6000	2454	2.65	6.75	14.00		6000	2148	2.31	5.86	12.05	26 16

10-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet			
		2500	5000	7500	10,000			2500	5000	7500	10.000			2500	5000	7500	10,000
1000	313	0.06	0.14	0.21	0.28	1000	268	0.05	0.12	0.18	0.24	1000	235	0.05	0.11	0.16	0.21
2000	627	0.27	0.56	0.84	1.12	2000	537	0.24	0.48	0.72	0.95	2000	470	0.21	0.42	0.63	0.84
4000	1254	1.11	2.25	3.37	4.56	4000	1075	0.95	1.92	2.88	3.88	4000	941	0.84	1.68	2.53	3.38
6000	1881	2.52	5 15	7.73	10.62	6000	1612	2.16	4.38	6.57	8.95	6000	1411	1.89	3.81	5.76	7.75
8000	2508	4.54	9 37	14.06	20.06	8000	2150	3.86	7.82	11.73	16.54	8000	1881	3.38	6.87	10.46	14.17

12-INCH PIPE.

		Length of Pipe in Feet.						Length of Pipe in Feet.						Length of Pipe in Feet.			
		2500	5000	7500	10,000			2500	5000	7500	10,000			2500	5000	7500	10,000
2,500	530	0.17	0.35	0.52	0.68	2,500	455	0.15	0.30	0.45	0.59	2,500	398	0.13	0.27	0.39	0.53
5,000	1061	0.70	1 41	2 11	2.84	5,000	910	0.62	1.21	1.81	2.42	5,000	796	0.53	1.05	1 58	2.11
7,500	1591	1.59	3.15	4.73	6.45	7,500	1365	1.35	2.69	4.03	5.53	7,500	1193	1.18	2.37	3.59	4.81
10,000	2122	2.83	5.77	8.66	11.95	10,000	1820	2.40	4.89	7.34	10.05	10,000	1591	2.11	4.27	6.46	8 69
12,500	2652	4.45	9.19	13.79	19.59	12,500	2275	3.79	7.76	11.64	16.19	12,500	1989	3.32	6.73	10.25	13.88

105 pounds gage, or 120 pounds absolute. What will be the terminal pressure and the loss of head? The pressure here assumed is not unusual in the best practice of the present day.

Note that d^5 (8^5) is 32,768, and p^2_1 (120^2) is 14,400. Substituting these values the statement and solution is as follows:

$$\frac{4000^2 \times 5000}{2000 \times 32{,}768} = 1220 = p^2_1 - p^2_2 = 14{,}400 - p^2_2$$

Then,

$$p^2_2 = 14{,}400 - 1220 = 13{,}180$$

and

$$p_2 = 114.80 \text{ pounds}$$

absolute terminal pressure; hence the loss of pressure is,

$$120 - 114.80 = 5.20 \text{ pounds.}$$

The foregoing example shows what may be considered a suitable rate of pipe transmission, or a flow which should not be much exceeded in practice. The free air in this case being

4000 cubic feet per minute, and the initial absolute pressure being 8 atmospheres, the actual volume, assuming that aftercoolers are used and that the air is at normal temperature, will be only 500 cubic feet per minute. The volume content of an 8-inch pipe is 0.349 cubic feet per foot of length; therefore the rate of flow will be

$$500 \div 0.349 = 1432 \textit{ feet}$$

per minute. A handy limit figure to keep in mind is the round number 1500 feet per minute.

The loss of pressure will be a little more than proportional to the squares of the volumes of free air. That is, if in this case the volume of free air had been doubled, making 8000 cubic feet instead of 4000 cubic feet, the loss of head would have been 22.44 pounds instead of $5.20 \times 4 = 20.80$ pounds.

It is worth while to note how the pressure loss is diminished as the pressure is increased, due to the reduction of volume. Thus, in 1000 feet of 1-inch pipe, transmitting 50 cubic feet of free air per minute, the pressure losses for increasing initial pressures would be as follows:

Initial Pressures.	Loss of Press.
45 pounds gage	11.52 pounds.
60 pounds gage	8.86 pounds.
75 pounds gage	7.24 pounds.
90 pounds gage	6.14 pounds.
105 pounds gage	5.33 pounds.
120 pounds gage	4.71 pounds.
135 pounds gage	4.23 pounds.
150 pounds gage	3.83 pounds.

Of course, no tables can be compiled which will cover the various requirements of compressed-air practice, but the figures herein given may at least furnish a working idea of the probabilities, and may be of service in a general way in preliminary estimates, or may serve to detect errors or inconsistencies which are apt to occur in the most careful figuring. No precise agreement with actual practice can be expected, as conditions which affect the result are so numerous.—*Power and the Engineer.*

BEAVER DAM-AGES

A land company at Stanhope, N. J., recently decided to construct an artificial pond in a section which was being developed, and in building the dam the engineers tore down a dam which had been built at the same spot by beavers. The engineers' work was completed only a short time ago; the beavers in the meantime had remained in seclusion so long that they had been entirely forgotten. A few days later, however, there appeared another and a larger dam of beaver manufacture, below the masonry dam, and before the men awoke to what was going on their new masonry dam was entirely submerged. Inasmuch as the beavers have made a larger pond than the engineers had planned, the latter are said to be inclined to pass by the slight on their work and to accept the gift.

The New Jersey engineers may believe that beaver dams are a good thing, but out near Steamboat Springs, Colo., according to another press report, there is a certain rancher who has a different opinion. Beavers on his ranch have dammed up his irrigation ditch so that the flow of water through his land has been stopped. Not long ago they filled the ditch with such a strong dam that it took two men an hour to demolish it and permit the water to flow unobstructed. The very next night the beavers did another construction job only a few yards from the first. That also was demolished, but to no avail, as the beavers immediately erected another dam. As a final resort, the rancher applied to the State Game Commission for permission to kill the beavers, claiming that unless this was done they would next be damming up Bear River and would thus deprive a number of other farmers of waters necessary for irrigation.

The Canadian Pacific Railway is experiencing difficulty at different places between White River and Cartier on account of beaver dams being erected and flooding its lands. At one place a dam was erected in the centre of a culvert, and part of the filling had to be removed in order to do away with it. When this was done the beavers built another a little further down the stream, and this also had to be removed on account of the backwater.

It seems to be the general opinion that the Government should declare an open season for a year and give the Indians and settlers a chance to dispose of the surplus beaver and otter.

A centrifugal milk tester burst Dec. 29, in the laboratory of the New York State College of Agriculture at Ithaca, N. Y. An instructor and four students were injured.

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COMPRESSED AIR FOR MINE HOISTING

It is getting to be now quite generally realized by engineers that for the larger problems of power transmission compressed air offers often the best ultimate solution, and accordingly we find it being adopted in many places in extensive open air operations for driving isolated pumps, hoists and other machines for which heretofore steam has been the only power thought of. The wisdom of such employment, as, for instance, on the Panama Canal, the N. Y. State Barge Canal, in various dam and waterworks constructions, quarries, etc., cannot be questioned. One important characteristic of compressed air is that it costs practically nothing except when it is actually doing work. There is no loss by condensation or heat radiation and there need not be any appreciable loss by leakage, and it can be stored in at least sufficient volume to be instantly ready for work of an intermittent character.

It was therefore entirely to be expected and should come to no one as a surprise that some of the larger copper mining companies are now preparing to use compressed air for driving their large mine hoists. While this is of course a new departure, or the extension of compressed air service into a new and important line of employment, it is not at all to be regarded as a blind experiment. Engineers in these days know what they are doing. Experience has assured them in advance that economy, reliability and convenience are to be secured, although the actual figures can only be determined by the records made.

The companies we have now in mind are the Anaconda Copper Company at Butte, Montana, and the Miami Copper Company of Arizona. The ultimate source of power for the Miami Company in this case will be steam generated by oil fuel, which in turn will generate electric current, the latter driving the compressors and also other machinery, the air being used as usual for rock drills and the usual deep mining equipment as well as for the main shaft hoists. The air for the mine hoisting engines will be preheated and also heated again between the compound cylinders, which of course will greatly reduce the volume of air required or the actual power consumption. The previous records of these companies as to hoisting and other service, which, it is understood, have been kept with care will give relia-

ble data for comparison with these later and more elaborate methods.

DISASTROUS AIR-GAS EXPLOSION

An unusual and a phenomenally disastrous gas explosion occurred Dec. 19 at the battery house of substation No. 1 of the New York Central and Hudson River R. R. Company's new Grand Central station terminal in New York city. There is a large storage here of Pintsch gas kept for supplying the train lighting service, and a train not under control broke off a main gas pipe at a considerable distance from the reservoirs, so that gas was escaping for about a half an hour before it was shut off. It is estimated that 14,000 cubic feet of gas escaped and mixed with air under the battery house and this explosive mixture was by some means ignited, wrecking the building and extending its destructive effect for a considerable distance around, a passing trolley car being wrecked and several of its passengers killed.

There have been of course many escapes of gas in much greater volume than this through accidents to gas holders or otherwise, but the gas has usually been free to rise in the air and no disaster has resulted. The capacious mixing chamber which existed in this case in the station excavation under the building and the igniting spark, say from an electric wire, at the opportune moment comprise a combination which sufficiently accounts for the disaster.

Engineering News presents an interesting computation showing the possible force of explosions of air-gas mixtures. It says:

Suppose we take a volume of 100 cu. ft. of gas of 600 B. T. U. per cu. ft. calorific power. When mixed with air in the proportions for most violent explosion the mixture could be contained in a small room about 12 ft. cube. The total heat units in this gas would be 60,000 B. T. U. and the total foot-pounds of potential energy would be 60,000 x 772=46,320,000 ft.-lbs. If this gas were exploded in small quantities behind a piston in a gas engine cylinder, something like 15 to 25 per cent. of this could actually be obtained as mechanical energy; and given proper mixture, something like this energy will actually be generated when the gas is exploded in a confined or partially confined space and will be exerted against any obstacle. This means that only 100 cu. ft. of gas exploding when mixed with air may have a potential destructive power of over 10,000,000 ft.-lbs.; or it could lift a structure weighing a thousand tons to a height of 5 ft.

AVIATION

Monthly publications are much too slow to keep the public informed of the new records, the incidents and especially the accidents in aviation and it is seldom that Compressed Air Magazine attempts to give any "news" in this line.

A height record of 11,474 feet was reported to have been made by Archibald Hoxsey on Dec. 26, at Los Angeles, Cal., with a Wright biplane flyer.

What is claimed as a world record for length of flight with a passenger was made by Lieut. Camerman, near Paris, on Dec. 21, 355 miles being covered in 5 hours and 55 minutes without alighting. A Bleriot monoplane was used.

An amateur aviator, Cecil S. Grace, on Dec. 22, attempted to make a trip by aeroplane from Dover to Calais and return. The first half was safely made, but on the return the machine disappeared in the fog and no trace has been found.

On Dec. 28, at Issy, France, an aviator named Laffant and a passenger were killed.

John B. Moisant, who was the first to fly across the English Channel with a passenger, and who snatched the $10,000 prize from Claude Graham-White by his flight around the Statue of Liberty in October, fell with his monoplane at New Orleans on the last day of 1910 and was killed.

On the same day Archibald Hoxsey, whose height record of a few days before is mentioned above, fell with his biplane at Los Angeles and was killed.

Both these men were trying to make new records. On the day before Hoxsey had flown to a height of 10,000 ft., passing over Mount Wilson, the highest peak of the mountain range which rims the valley in which the cities of the "Orange Belt" lie.

Lieut. Caumont, of the French Army Aviation Corp, fell from a height of 60 feet at Versailles on Dec. 30, while trying a new monoplane, dying a few hours after the accident.

A distance record for aeroplane flight in 1910 was made by Maurice Taberteau. In a continuous flight of 7 hours 45 min., 362.7 miles were covered.

TRADE PUBLICATIONS

George Oldham & Son Co., Frankford, Philadelphia, Pa. Catalog C. 52 pages and cover, 6x9 inches. Describes Pneumatic Tools and Appliances, and shows them in use.

Temple-Ingersoll Electric-Air Rock Drills, Instructions for Installing and Operating with Duplicate Part Lists, Ingersoll-Rand Company, 11 Broadway, New York, 36 pages and cover, 6x9 inches.

Bentz System Company, Newark, N. Y., 20 pages and cover, 6x9 inches. Describes apparatus for air-washing, ventilating and heating purposes, with full page half-tones of buildings where it is installed.

Buffalo Forge Company, Buffalo, N. Y. General Catalogue No. 178. 304 pages, 6x9 inches. Describes and gives full details of the variety of machinery manufactured, forges, blowers, blacksmith's and boilermaker's tools, woodworker's tools, etc.

Blaisdell Machinery Company, Bradford, Pa., The Blaisdell Automatic Sewage Ejector Catalogue 50 pages, 6x9 inches. This ejector is operated either by air or steam. Its mode of operation and details of installation are described with some fine photos of prominent buildings in which it is used.

Ingersoll-Rand Company, 11 Broadway, New York. Class "PB" Duplex Power Driven Air Compressors, Form No. 3007, 24 pages, 6x9 inches. This class of machines are described in detail with tables of principal dimensions. The drive is either by belt or rope, and compression is either single or two stage with efficient intercooling and close regulation of output.

Baldwin Locomotive Works, Philadelphia, Pa., Record No. 68. 36 pages and cover, 6x9 inches. Mallet Articulated Locomotives. These novel and interesting machines are described and beautifully illustrated, the largest type having two complete engines with compound cylinders and four pairs of drivers to each or eight pairs of drivers to the complete locomotive with a total weight, with tender, of 700,000 lbs. and a tractive force of 96,000 lbs.

The Bristol Company, Waterbury, Conn. Bristol's Recording Gages, 48 pages, 8x10½ inches. This catalogue not only describes and illustrates a great variety of gages but gives a much greater ranger of graduations for different lines of service, reaching all pressures from a perfect vacuum to the highest obtainable, with readings in inches of water, inches of mercury, ounces or pounds per square inch, atmospheres, etc., with all possible graduations under the metric system also.

A MANUFACTURER'S LIBRARY

The Commercial Bureau Company has an elegant and spacious apartment in the Hudson Terminal Building, 50 Church street, New York, which is fully equipped as a Manufacturer's Record or Reference Library. It is free to all who wish to consult matter on file. Out of town visitors are invited to use the library for headquarters. There are free desks or rooms for the temporary use of Manufacturers or buyers, with all the usual facilities for business.

ROCK TEMPERATURES AND DEPTH

Attempts are being made to compare and reconcile the temperatures at different depths in different parts of the earth.

At Witwatersrand mines (South Africa) rock temperatures were taken at intervals of 1000 feet showing temperatures varying from 68.75 degrees F. at 1,000 ft., to 102.35 degrees at 8000 ft., or a general rate of increase of 1 degree for each 250 ft. of depth.

In the Lake Superior copper mining field the rate of increase is given as 1 degree for each 209 ft of depth.

At the St. John Del Rey mine, Minas Gares, Brazil, an average increase is shown of 1 degree for approximately every 156 ft. of depth down to a depth of 4024 ft., the rock at that depth having a temperature of 95 degrees F.

At Bendigo, Victoria, Australia, the rock temperature is given as 110 degrees F., at a depth of 4000 ft., and that of issuing water at the same depth as 114 degrees F. At the Adelbert mine in Bohemia, where silver-lead ores are mined, the rock temperature is 113 degrees F. at a depth of 3600 ft. At the Kalgoorlie mines, Australia, observed rock temperatures show practically no variation between 1400 ft. and 2300 ft., the temperature at each point being given as 84 degrees F. At two intermediate points (1700 ft. and 2000 ft.) 83 degrees F. is recorded.

The easiest and most obvious conclusion from these figures is that no general rule can be given for the increase of rock temperature.

with depth, the increase being determined by local conditions. When, however, it is remembered that the greatest depth given above, 8000 ft., is only 0.0003 of the earth's radius no reliable average could be expected. The general fact of the increase of temperature is all that we are sure of.

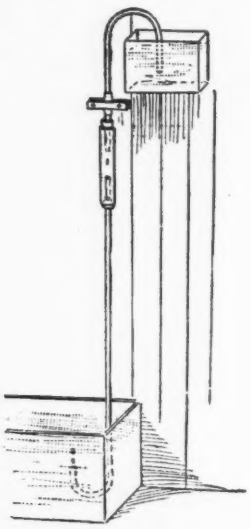


FIG. 1.

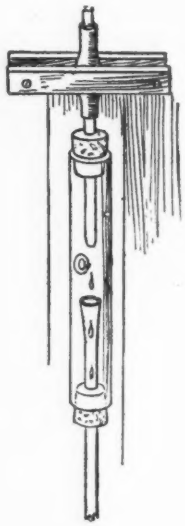


FIG. 2.

AERATING WATER FOR AQUARIUM AND OTHER USES

A simple way of producing air pressure sufficient to aerate water is by the use of a siphon as shown in Fig. 1. The siphon is made of glass tubes, the longer pieces being bent on one end as shown. The air receiver and regulating device are attached to the top end of the lower tube, as shown in Fig. 2. The receiver or air inlet is the most important part. It is made of a glass tube, ¾ in. diameter and 5 in. long. A hole is filed or blown through one side of the glass for the admission of air. The ends of the smaller glass tubes are passed through corks having a diameter to fit the ends of this larger tube. The ends of these tubes should be so adjusted that the continuous drops of water from the upper will fall into the tube below. The succession of air bubbles thus imprisoned are driven down the tube and into the tank below.

The regulator is placed in the tube or siphon above the air receiver. Its purpose is to retard the flow of water from the siphon above and make it drop rapidly. It consists of a rubber connecting tube with two flat pieces of wood clamped over the center and adjusted with screws. The apparatus is started by clamping the rubber tube tightly and then exhausting the air in the siphon tube, then placing the end in the upper reservoir and releasing the clamp until the water begins to drop. If the reservoir is kept filled from the tank, the device will work for any length of time.—*Popular Mechanics.*

PNEUMATIC BOILER-TUBE SCALER

There is now being manufactured in Birmingham, England, a pneumatic tube scaler. This scaler consists of a special pneumatic hammer of a size to permit it to pass easily through the tubes. At the end that enters are fitted six vibratory cutters, arranged in a circle around a central ram and anchored by lugs to an internal collar at the front end of the tool, the interior of the cutter circle being coned to receive the blows of the coned fore end of the piston or hammer. The device is valveless and the ram is its only moving part. It is designed to give from 2,000 to 3,000 strokes per minute, and it is said that it can be regulated to anything within that range by the pressure of air employed; that it requires an average working pressure of 80 pounds, and that by throttling the supply the blows may be regulated to suit any particular degree of hardness or thickness of the scale. In operation the longitudinal blows of the hammer shank cause the cutters to deliver corresponding circumferential blows against the lining of scale on the interior of the tubes. The separated scale is blown ahead by the exhaust air. The tools vary in size from ¾ to 7 inches in diameter. The design of the tools varies somewhat for other uses of a similar kind.—*Consular Reports.*

ELECTRIC AIR HEATERS FOR ROCK DRILLS

R. G. Mackie, in the Journal of the Transvaal Institute of Mechanical Engineers discusses the use of small electric air heaters. He says:

The air temperature at the drills would be higher, and the expansive effect of the hot air used to advantage. The compound rock drill would then have an increased economy over the single-cylinder drill; the exhaust temper-

ature would probably be low enough as to not affect the temperature of the mine, and these drills would, in all probability, be more used. The radiation losses would be more easily maintained, as the expansion and contraction would only take place in comparatively small pipes. In the case of large rigid pipes with heaters for the entire air supply, the expansion effect of the hot air would cause much trouble, and expensive expansive joints and bends would have to be inserted in the mains. Unless these large mains were covered with some non-conductor of heat, the radiation losses would be great, thus tending to increase the mine temperature, so that everything is in favor of small heaters close to the work.

The quantity of heat available from an electric current which passes through a high resistance is proportional to the current squared multiplied by the resistance, or C^2R. By raising the temperature of the air, the amount of work it is capable of performing becomes proportionally greater, and when a cheap electrical supply is placed at the disposal of the mines the re-heating of compressed air under ground will, I hope, become economical.

A SUBMARINE ENDURANCE TEST

How long crews of submarines can remain under water without a renewal of air was sought to be determined by a somewhat unpleasant experiment to which the men of the Danish submarine boat Dykkeren (Diver) have been subjected. The crew numbered eleven, and for these 65 cubic meters of air was available. An adult, scientists say, needs half a cubic meter of air an hour, but it was found that in an enclosed space air deteriorates so rapidly that a calculation based on this figure does not hold good.

The Dykkeren remained under water for twelve hours, but only nine of these the crew passed in comparative comfort. After that the vitiated atmosphere necessitated quicker and quicker breathing to provide the necessary amount of oxygen, and the sailors became seized with a gradually growing sense of terror. They held out bravely, but toward the end they found themselves unable to speak except by a supreme effort of will.

Then the order was given to ascend, and the men tumbled over each other in their anxiety to get at the fresh air. Eye-witnesses say that they lay about the deck gasping like fish out of water. The quick return to normal conditions had bad effects, for the sudden incursion of fresh air into the lungs caused a very painful burning sensation which did not leave them for some time.

SKILL OF OIL WELL DRILLERS

Drilling oil wells is a business concerning which technical literature has had little to say. In general, the work has been in charge of mechanics rather than engineers, and there are so many ways in which a driller can either help or hinder the work that the men have generally been given a free hand. Usually, too, when a field is under development speed is all-important. Competent drill-men have had neither time nor inclination to write of their work. It should be remembered that the drill crew works in the dark. It is impossible either to see the bit at work or to examine the hole when completed and determine just what was the difficulty. Among other notable things accomplished under these conditions, are the handling of a free-swinging column of eight-inch pipe half to three-quarters of a mile long; passing such a pipe to one side and around broken casing or tools in the bottom and continuing the hole; cementing off heavy flows of water nearly a mile below the surface; picking up from the bottom broken tools; underreaming so as to advance casing, and many other equally striking things. In California, wells have been completed where the pipe was broken and passed seven times, and yet a casing was landed successfully at the bottom. The technical achievements of the oil-men deserve more notice than they have received.—*Mining and Scientific Press.*

NOTES

Calumet & Hecla's recovery of copper from its conglomerate lode is now only 29 lbs. to the ton, just about half what it was 10 years ago, and the cost of getting ore to the surface has steadily increased with depth.

With a nozzle 1⅜ inches in diameter and a pressure of 100 pounds, a stream of water can be thrown vertically 103 feet, or horizontally 96 feet and will discharge 674 gallons of water per minute.

Those interested in the conservation of natural resources will be encouraged by English

press accounts of the extension of the Yorkshire coalfields, which indicate that they have 35,000,000,000 more tons of coal available for mining than was supposed.

The roar of the air exhaust of a Cameron sinking pump which is used to unwater the shaft of the Butte-Alex Scott Copper Company at Butte, Mont., has been eliminated by passing the spent air through a check valve into the water or discharge column.

Baccarat, France, has the honor of producing the first glass that is unbreakable. The new process has been successfully applied to the manufacture of lamp chimneys for use in coal mines containing much firedamp. The glass makers of Baccarat have also succeeded in increasing the elasticity of the glass.

New York is the center of the great piano industry of the world. In the year, 1909, the output of pianos alone was valued at over $25,000,000; representing 180,000 instruments. Every conceivable class of musical instrument is manufactured in this city. The two largest piano factories in the world are located in "Little Old New York."

The most highly civilized people on earth use the largest quantities of sugar per capita. The consumption of sugar increases with the wealth and refinement of a nation. England and the United States use sugar in much larger quantities than any other country in the world. The average consumption of sugar per capita with the people named is more than seventy-five pounds per year.

In a large colliery district close to Manchester a great number of miners travel by train to and from their work. On arriving at the station the smokers, and that means practically every one, stick their pipes into various corners and holes of the platform woodwork. There they remain till going back time, when each man always finds his pipe just as he left it.

The official records show that eighty-two million dollars worth ($82,000,000) of merchandise originating in the United States crossed the Isthmus in 1909, which sum, it may be assumed, will be much increased as soon as the Canal is opened, saying nothing of what will be coming to the United States over the same route.

It has always been thought that the disintegration of stone was the result of heat and cold and corrosion caused by the weather. A scientist has proved that it is really caused by a germ, and, when stone is treated with an insecticide the disintegration ceases. All this leads to the inevitable conclusion that there is either vegetable or animal life in the stones, and if in stone where does life cease?

The Baltimore & Ohio Railroad has erected a new double-track steel bridge over the Cheat River at Rowlesburg, W. Va. The bridge, consisting of two spans of 115 and 125 feet, respectively, was put together nearby, and when all was ready, hydraulic machinery was employed, the old bridges were removed and the new bridge was rolled into place, all within 20 minutes, and without delay to traffic.

Grouting the surface of concrete in order to make it smooth, leaves it subject to unequal wear, owing to the lack of uniformity in the degree of hardness in such a thin layer of cement. The "set" of a thin sheet of cement is not the same as that of a large mass. For this reason the tops of concrete blocks for setting heavy machinery should not be made "true" by grouting, but by dressing down after the block has set, in the same way as the surface of a stone would be finished.

The Pennsylvania Railroad is said to be considering the installation at Union Station, Pittsburg, of a device for registering automatically the number of passengers passing through the trainshed gates. The apparatus comprises a stream of compressed air which plays continuously across the passageway and holds open a circuit, except when it is interrupted by the body of the person traversing the passageway. These interruptions register the number of persons passing.

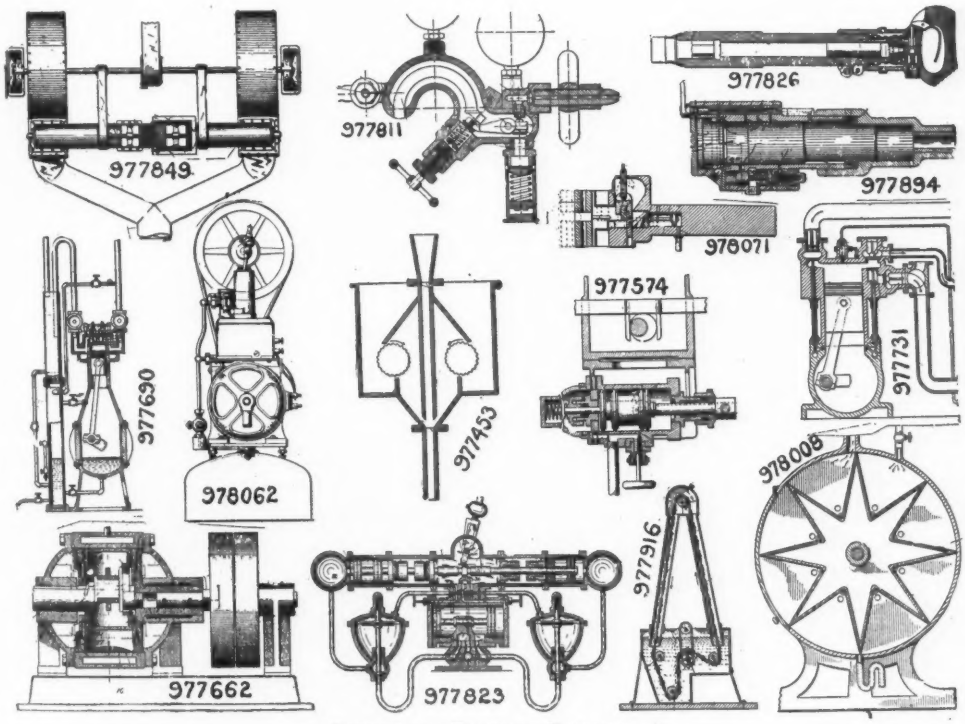
Sir William Ramsey stated recently that the cost of radium was now $2,100,000 per ounce, which is slightly less than a year ago, when, in an address at the laying of the cornerstone of the radium factory at Limehouse, he said that the value of the substance was $2,500,000

an ounce, which was at the rate of $90 per milligramme. In January, 1910, the price was said to be $3,000,000 an ounce. About a year ago there was only a quarter of a pound of radium in the whole world, and the quantity is not much greater at the present time.

Official tests of the many valuable hardwoods native to Western Australia have made known the extraordinary properties of yate, believed to be the strongest of all known woods. Its average tensile strength is 24,000 pounds to the square inch, equalling that of good cast iron. But many specimens are much stronger, and one was tested up to seventeen and a half tons to the square inch, which is equal to the tensile strength of wrought iron. The tree grows to a maximum height of 100 feet, and has sometimes a diameter of 2½ or even 3 feet."

The consumption of silver in the photographic industry is probably seldom thought of, but it is likely that at least 4,000,000 oz. are annually consumed in this industry. George Eastman, of the Eastman Kodak Company, says: "We are now using about 125,000 oz. of silver bullion per month. We have no accurate means of estimating the total amount of silver used in our industry in the country, or in the world, but should imagine that altogether it would aggregate several times this amount." This use of silver so disperses it that it is not recoverable under present practice.

Notwithstanding its new tunnels under both the Hudson and East Rivers, the Pennsylvania Railroad has under consideration the construction of an East River bridge. This was made known in a letter from Vice-president Samuel Rea, as read before the Municipal Art Society, of New York. "I hope that before very long," he writes, "our company will be actively engaged in the construction of the bridge across the East River, and we will take all steps in our power to make this bridge not only impressive because of its proportions, but beautiful in its design, and a monumental feature of the City of New York."



PNEUMATIC PATENTS, DECEMBER 6.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

DECEMBER 6.

977,453. SAND-BLAST DEVICE. ALBERT JORN, Jr., Waukegan, Ill.

977,528. AEROPLANE. AUGUSTUS F. W. MACMANUS, San Antonio, Tex.

977,549. COMBINED AIR-RIFLE, RUBBER BALL, AND POP-GUN. ERNEST S. ROE, Plymouth, Mich.

977,555. OCEAN - AIRSHIP. REINHOLD SCHMIECHEN, Ledyard, Iowa.

977,574. FLUID-ACTUATED MOTOR. JOHN S WARD, Chicago, Ill.

977,662. COMPRESSOR. JOHN LEVEY, Chicago, Ill.

977,690. GAS-PUMP. ALFRED S. WHITE, Chicago, Ill.

977,731. THERMODYNAMIC MACHINE. JOSEPH EMILE HAENNIG, Belfort, France.

1. In the transformation of heat into motive force, the process which consists in successively compressing, heating, expanding and cooling a part of a motive fluid, driving a motor by the expanding of said part of the motive fluid, and submitting another part to vaporization and then to condensation, by communication of heat units from it to said first part.

977,811. PRESSURE-REGULATOR. JACQUES MANDET, Paris, France.

977,823. CONTROLLING-VALVE FOR PUMPING SYSTEMS. FRANCIS S. MILLER, Indianapolis, Ind.

1. A controller for air lift systems comprising a main valve, a piston structure for shifting the same, a valve controlling the flow of motive fluid to said piston structure, a piston structure connected with said second valve, and means for controlling the flow of motive fluid to and from said piston structure in opposite directions, said means comprising a pair of pressure-controlled valves, and pressure connections for said pressure-controlled valves.

977,826. PNEUMATIC TOOL. REINHOLD A. NORLING, Aurora, Ill.

977,849. PNEUMATIC ELEVATOR. GEORGE BERNERT and JACOB BERNERT, South Germantown, Wis.

977,856. AIR-BRAKE SYSTEM. JOHN DILLANDER, Temple, Tex.

977,894. PNEUMATIC DRILL. JONAS L. MITCHELL, Denver, Colo.

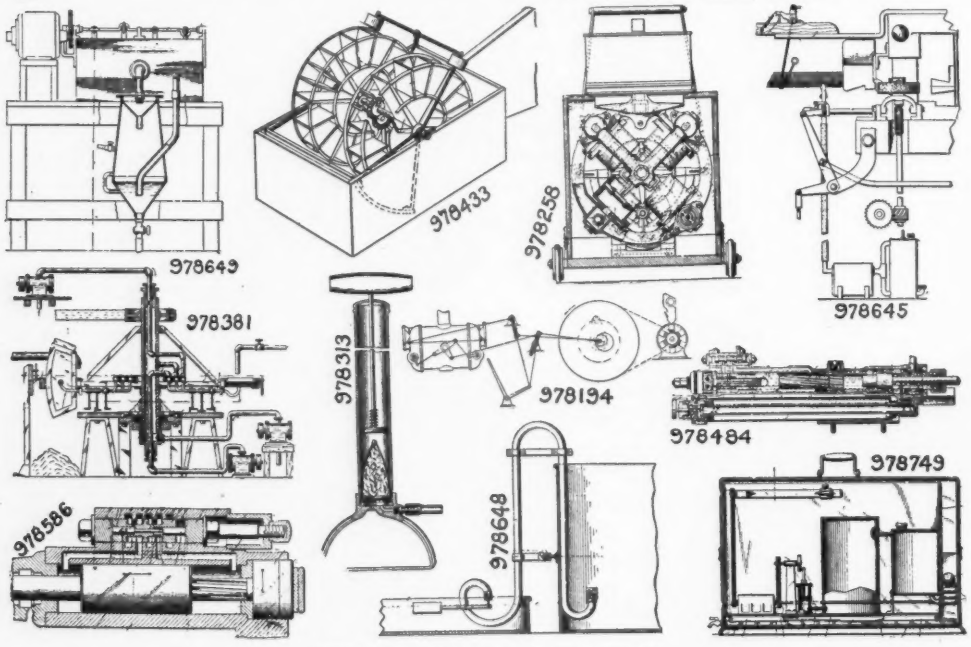
977,916. AIR-PUMP. SAMUEL R. WILLIAMS, Oberlin, Ohio.

977,997. FLYING-MACHINE. EDWARD BERTHOLF, Watkins, N. Y.

978,008. AIR-COOLING APPARATUS. GENNARO DRAMIS, Brooklyn, N. Y.

978,062. AIR-COMPRESSING APPARATUS. PERCY RUSSELL, New York, N. Y., and ADOLPH W. SCHRAMM, Riverton, N. J.

978,071. PNEUMATIC COUPLING. DAVID B. STANLEY, Maine Prairie, Minn.



PNEUMATIC PATENTS, DECEMBER 13.

DECEMBER 13.

978,167. PORTABLE VACUUM-CLEANER. CADWALLADER W. KELSEY, Philadelphia, Pa.

978,194. MOTOR-COMPRESSOR. BRUNO V. NORDBERG, Milwaukee, Wis.

1. In a motor-compressor the combination of an alternator, a synchronous motor, and an engine provided with means for converting it from a compressor into a motor and vice versa, and having a power transmitting connection with said synchronous motor.

978,198. PNEUMATIC-DESPATCH-TUBE APPARATUS. ALBERT W. PEARSALL, Lowell, Mass.

978,258. AIR-PUMPING APPARATUS. ERNEST L. B. ZIMMER, Minneapolis, Minn.

978,271-2. PNEUMATIC - DESPATCH - TUBE APPARATUS. JAMES T. COWLEY, Boston, Mass.

978,313. PUMP FOR MEDICATING AIR. JAMES A. LEE, Bellsville, Ohio.

978,381. SUCTION-FILTER. HARRY E. KIER, Colorado Springs, Colo.

978,433. WINDMILL. JOHN W. COLEMAN, Madrid, Iowa.

978,484. FLUID - PRESSURE - OPERATED TOOL. WILLIAM PRELLWITZ, Easton, Pa.

978,561. FUME-PRODUCING DEVICE. PETERSON H. CHERRY, Los Angeles, Cal.

3. A fume producing device comprising a receptacle for containing the fume producing material and a pneumatic device connected thereto to draw air into or expel it from the receptacle, said pneumatic device composing a closed case communicating with said receptacle and having a portion movable inwardly and outwardly to vary the volume within the case, a coil spring within the case, and a stud extending within said spring and serving as a guide therefor and as a stop for the movable portion of the case.

978,579. AIR-VALVE. PAUL J. GREBEL and WILLIAM J. THEIS, Chicago, Ill.

978,586. ROCK-DRILL. CHARLES A. HULTQUIST, Bisbee, Ariz.

978,642. AIR-RESERVOIR FOR MINES. PATRICK QUINN, Forbes Road, Pa.

978,645. PNEUMATIC SELECTOR FOR SHORT-WEFT LOOMS. HENRY E. RATHBUN, Worcester, Mass.

978,935. MECHANISM FOR LIQUEFYING AIR AND SEPARATING SAME INTO OXYGEN AND NITROGEN. JAMES F. PLACE, Glen Ridge, N. J.

978,937. COMPRESSOR. GEORGE H. REYNOLDS, Mansfield Depot, Conn.

978,981. ROCK-DRILL. GEORGE R. BENNETT, Denver, Colo.

979,044. PNEUMATIC SPRING. IGNATIUS J. STADELMANN, Los Angeles, Cal.

979,164. ELECTROPNEUMATIC TOOL. JOHN TEN EYCK HILLHOUSE, New York, N. Y.

979,165. COMPOUND COMPRESSED-AIR ENGINE. CHARLES B. HODGES, Pittsburg, Pa.

979,210-1. VACUUM CLEANING APPARATUS. LEMUEL WILLIAM SERRELL, Plainfield, N. J.

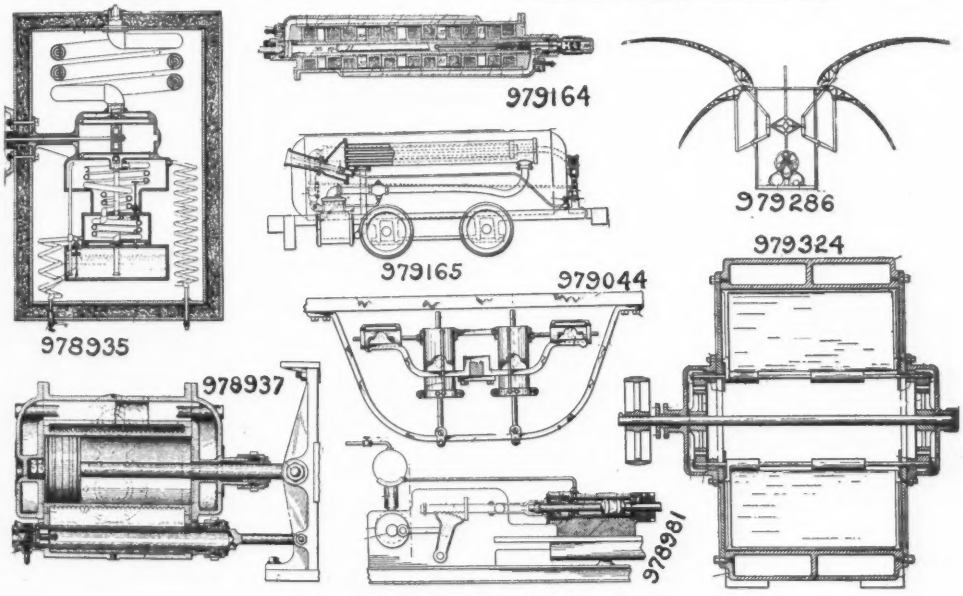
979,286. AERIAL NAVIGATOR. ROSCOE C. GORE, Tecumseh, Nebr.

979,324. BLOWER OR PUMP. FRANK J. MINER, Detroit, Mich.

DECEMBER 27.

979,435. VACUUM STEAM-ENGINE. CHARLES COMSTOCK, West Stockbridge, Mass.

979,436. VACUUM SUPPORTING DEVICE. JULIAN E. CORBIN, Alameda, Cal.



PNEUMATIC PATENTS, DECEMBER 20.

978,648. SIPHON FEEDING MECHANISM. EDWIN A. RHOADS, Goodland, Kans.

978,649. VACUUM CLEANING APPARATUS. LYMAN R. ROBERTS, Rutherford, N. J.

978,749. CLEANING-MACHINE. JOHN N. HOLLIS, Macon, Ga.

1. An apparatus of the class described, a casing, a motor supported upon the bottom of the casing, an air storage tank, a fluid receptacle in communication with the tank whereby the contents will be maintained under pressure, a pump communicating with the storage tank for supplying air thereto, a hollow rotatable tool shaft communicating with said fluid receptacle, and driven connections between the motor, pump and shaft whereby the said pump and shaft will be simultaneously operated.

DECEMBER 20.

978,916. PNEUMATIC CLEANER. FRANK J. MATCHETTE, Milwaukee, Wis.

979,472. FLYING-MACHINE. FRED GOEHNER, Buffalo, N. Y.

979,579. UTILIZING WASTE HEAT OF COMPRESSORS. FRANK SHUMAN, Philadelphia, Pa.

1. The mode herein described of utilizing waste heat of compressors, said mode consisting in causing the exhaust motive power fluid of the compressor engine to heat one portion of a power-developing agent having a relatively low boiling point, and causing the compressed fluid to heat to a higher temperature another portion of said agent.

979,617. PNEUMATIC RIVETING - TOOL. CHRISTOPHER WEATHERSON, Chicago, Ill.

979,788. VACUUM APPARATUS. EDWARD P. NOYES, Winchester, Mass.

2. Vacuum apparatus comprising an automatic internal-combustion motor adapted to mechanically pump its combustion-air charge, an anteriorly-extended air-suction pipe having a plurality of suction inlets one of which is pro-

vided with means for applying the motor suction to the performance of external work, and throttle-valves for the respective inlets controllable at will.

979,837. CONDUCTOR'S VALVE FOR FLUID-PRESSURE BRAKES AND SIGNALS. CLYDE C. FARMER, Chicago, Ill.

979,867. AUTOMATIC CHEMICAL AIR-LIFT. AUGUST LONG, Bayonne, N. J.

979,899. LINE-THREADING DEVICE. FRANK N. STEIGLEDER, Richmond, Va.

1. In a line threading device, the combination of a fluid pressure supply pipe having an opening therein and provided with a discharge nozzle, a bracket mounted upon the exterior of said pipe in proximity to said opening, a reel journaled upon said bracket, a line wound upon the reel and extending through said opening into the pipe and thence through the pipe and externally through the nozzle, and a traveler connected with the free end of said line, said traveler comprising a flexible stem carrying radially flexible disks.

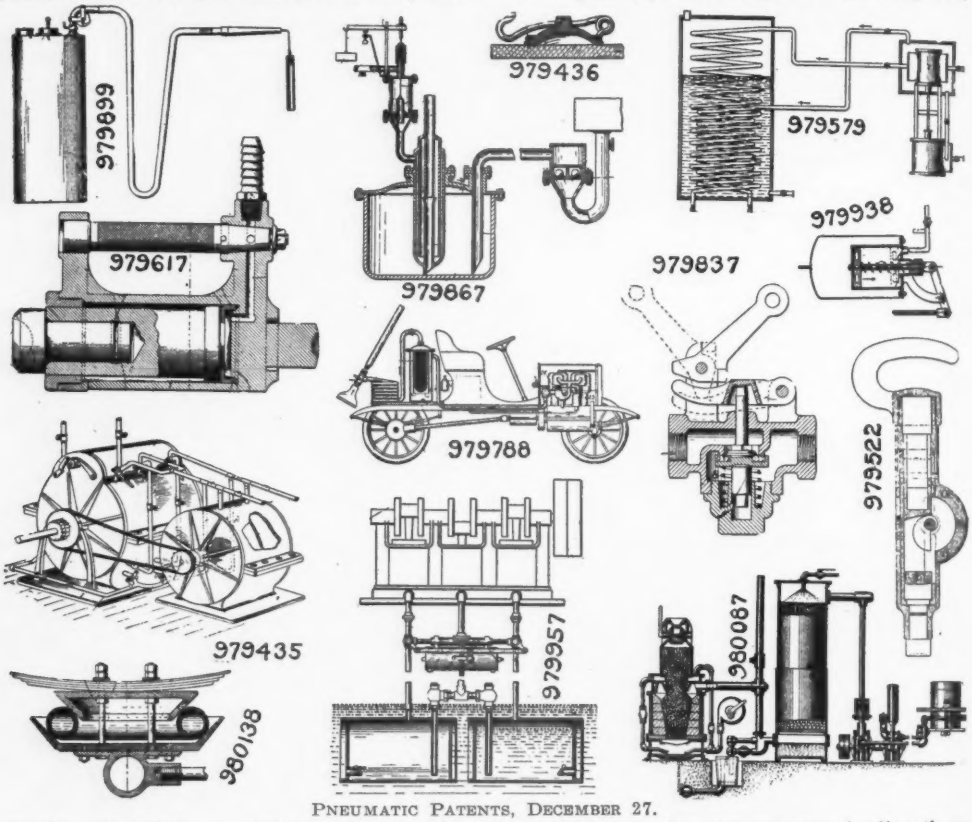
979,929. COMBINED AUTOMATIC AND INDEPENDENT RAKE. CHRISTOPHER P. CASS, Maplewood, Mo.

979,938. AUTOMATIC EMERGENCY-BRAKE FOR AUTOMOBILES. EMIL EISELT, Baltimore, Md.

1. An automatic emergency-brake for automobiles comprising, an air-tank, an air-cylinder having its inner end communicating with the air-tank and having a closed outer end, a piston movable in said cylinder, a brake operatively connected to the piston, a passage communicating with said closed outer end, and an emergency-valve in said passage, said cylinder being provided near its ends with air orifices communicating with the air-tank.

979,957. LIQUID-ELEVATING APPARATUS. GEORGE HARTFORD IRWIN, JOHN PERCIVAL CULLON, and FREDERICK KNOWLSON, Lindsay, Ontario, Canada.

1. The combination with an air compressor and two compression tanks arranged to be submerged in a body of water, of pipes connecting each tank with the air compressor, a flap valve at the bottom of each tank, a discharge pipe leading from each tank, a three-way faucet located on each pipe connecting the tanks with the compressor provided with suitable operating arms and designed to be one reversely set to the other, an independent pipe leading from the compressor, a controlling valve communicating with this pipe comprising a cylinder provided with an upward extension having a longitudinal passage-way with a central enlargement opposite the independent pipe and ball valve therein, and vertically disposed end passage-ways and double piston provided with a connecting rod,



PNEUMATIC PATENTS, DECEMBER 27.

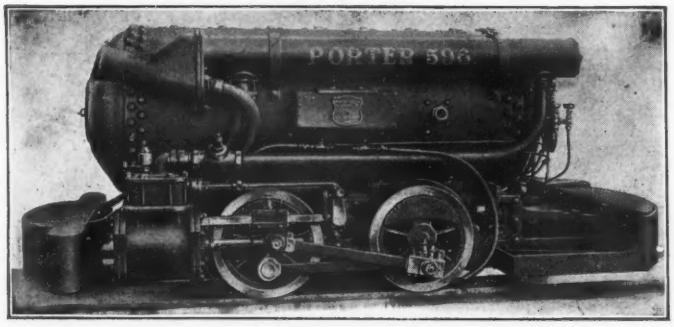
and spindles having passage-ways leading therethrough, tubular bosses formed on the ends of the cylinders into which the spindles extend, a pin extending from the connecting bar of the piston through a slot in the cylinder, an arm connected to the pin and a cross bar connecting the arms of the faucets to the arm on the pin and branch pipes leading from the cylindrical passage-way in the upper extension of the cylinder to the faucets as and for the purpose specified.

980,087. METHOD OF GENERATING HIGH TEMPERATURES. WILLIAM CHRISTIAN FINCK, Elizabeth, N. J.

980,138. PNEUMATIC CUSHION FOR VEHICLES. GEORGE J. BANCROFT, Denver, Colo.

980,172. WINDMILL. WILLIAM P. BRETT, Decatur, Ill.

PORTER COMPRESSED AIR
MINE AND INDUSTRIAL HAULAGE



A Two-Stage Compressed Air Gathering Locomotive—one of twenty built for the Pittsburg-Buffalo Company. Wireless, Sparkless. Two-stage features add fifty per cent. to the efficiency and reduce the cost of installation, making our air haulage the most economical as well as the safest, cleanest, handiest and most dependable mine haulage in the world.

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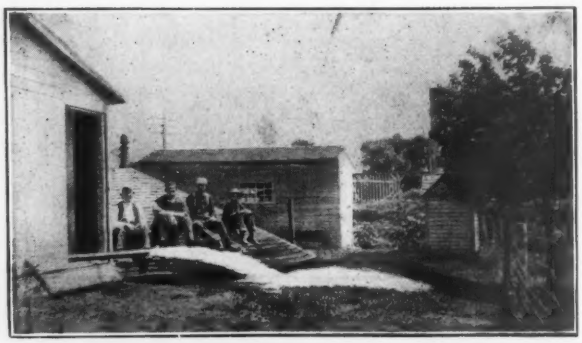

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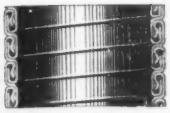

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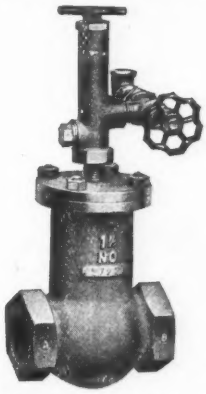

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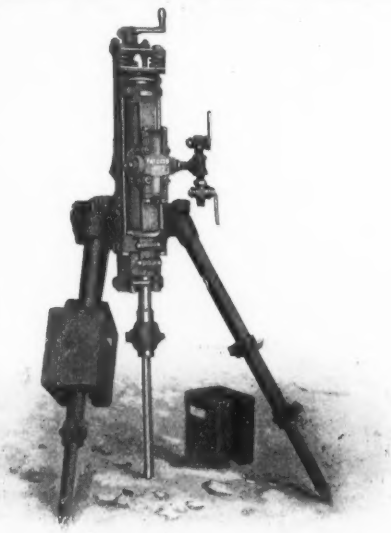

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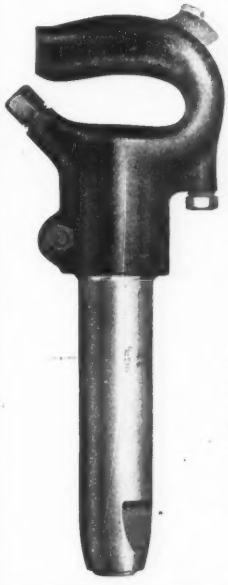

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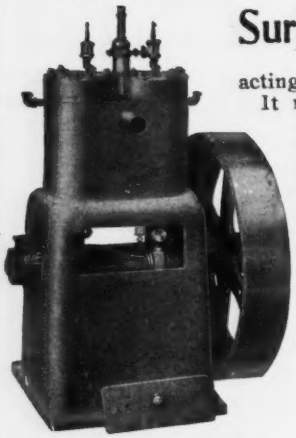

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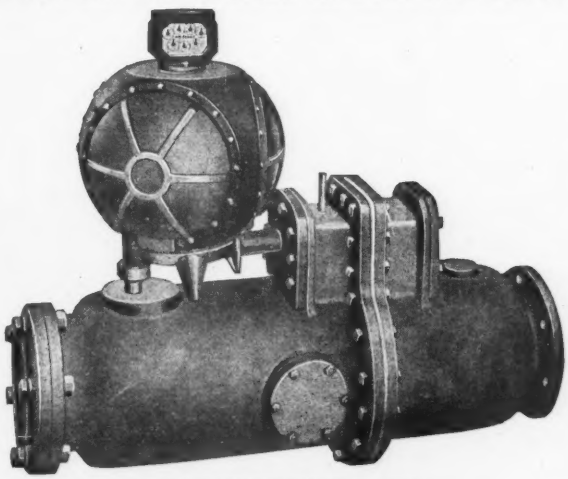

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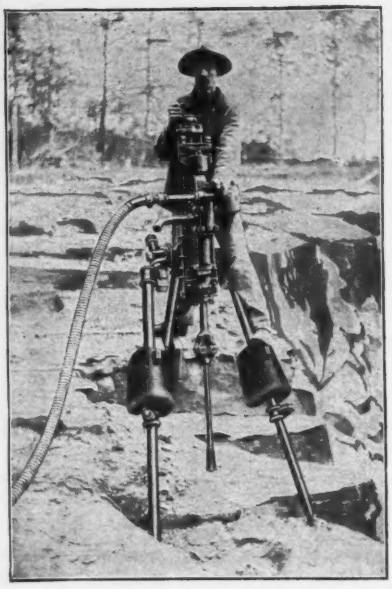

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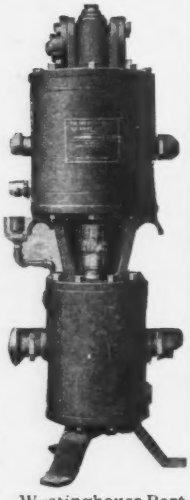

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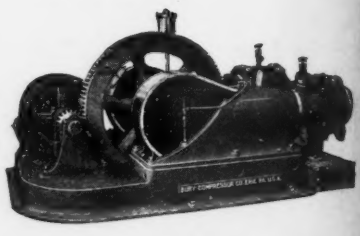

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